Animas River
Arrastra Gulch to Bakers Bridge

Ecological Risk Assessment

Overview

- Ecological Risk Assessment (ERA) Process
- Ecological Risk Assessment Tools
- Results
  - Benthic Macroinvertebrates
  - Fish
  - Wildlife; Not discussed in detail today
- Conclusions

Ecological Risk Assessment (ERA)

- Evaluates the likelihood that adverse ecological effects may occur or are occurring as a result of exposure to site contamination.
- ERA is designed to support decision making to mitigate risk where needed.
- Risks may include survival, reproductive impairment, growth impairment and loss of habitat.
- Risks are estimated at the population level (populations on site).

Exposure Units

- Cement Creek
  - Not discussed in detail today
- Mineral Creek
  - Not discussed in detail today
- Animas Upstream of Cement Creek to Arrastra
  - Data averaged across entire reach
- Animas from Cement Creek to Mineral Creek
  - Not discussed in detail today
- Animas downstream of Cement Creek
  - Data evaluated at individual stations due to distance between each location.

Exposure Point Concentrations

- Reasonable Maximum Exposure (RME)
  - 95% upper confidence level of the mean if dataset allows
  - Otherwise maximum value is used
  - Hardness dependent metals use 95% *lower* confidence limit of the mean.
- Central Tendency (CT)
  - Arithmetic or geometric mean

Measurement Endpoints or Lines of Evidence

- HQ Approach
- Site Specific Toxicity Testing
- Community or Population Surveys

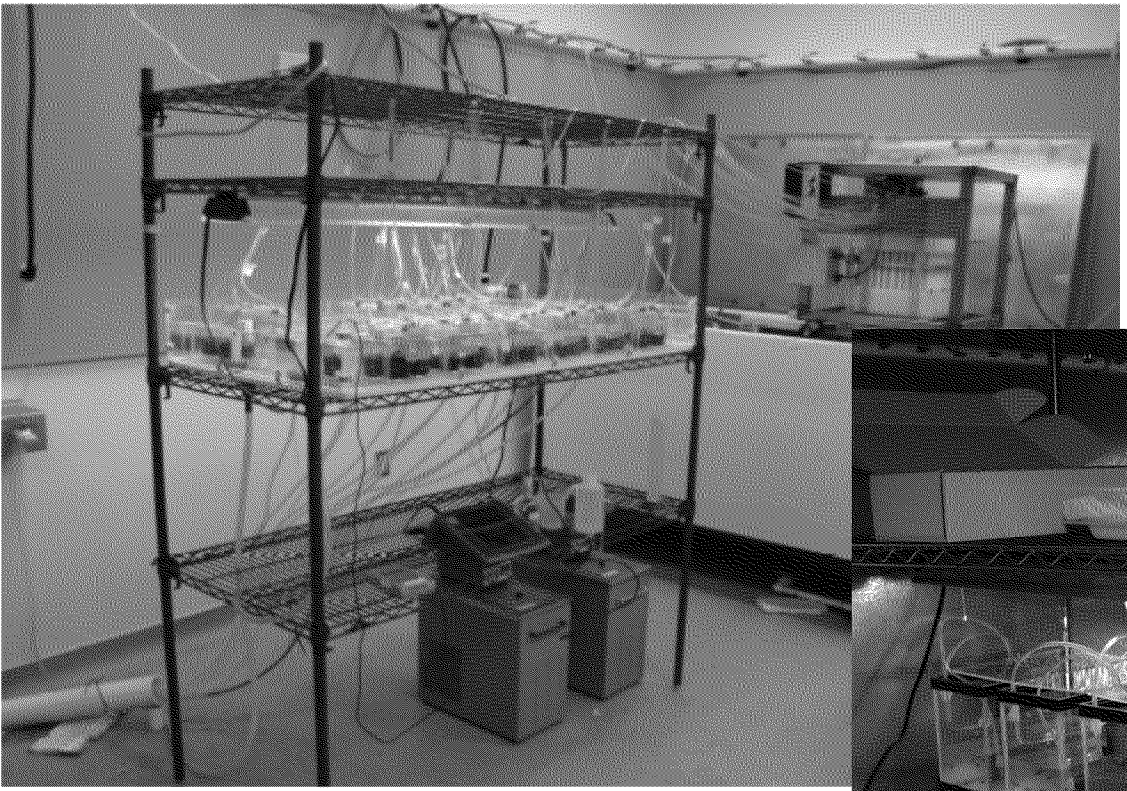
Hazard Quotient (HQ)

HQ = Exposure / Benchmark

HQ<1 = Acceptable risk

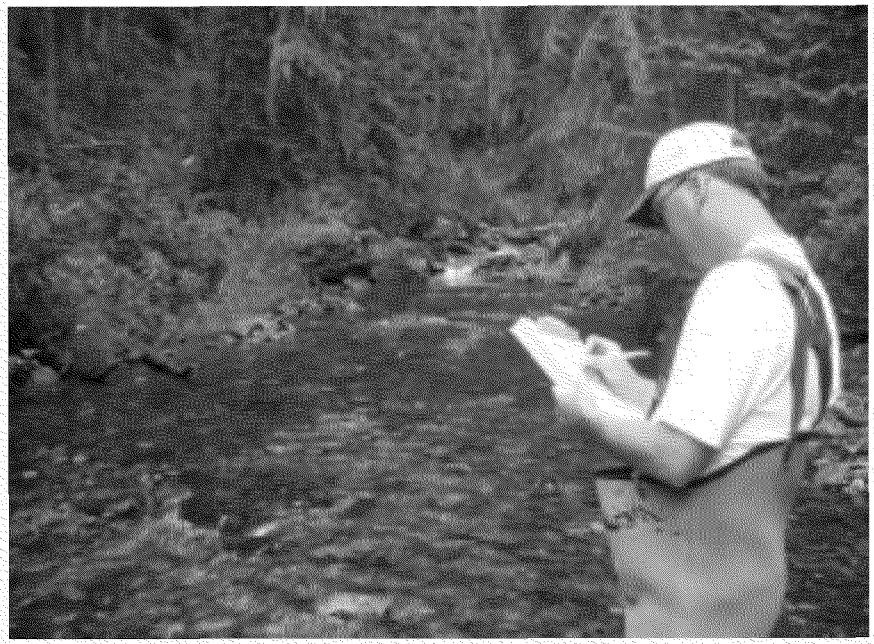
HQ>1 = Further evaluation warranted *or* unacceptable risk

Toxicity Testing



Community Surveys

Community Surveys-Habitat



HABITAT ASSESSMENT FIELD DATA SHEET—HIGH GRADIENT STREAMS (BACK)

Parameters to be evaluated broader than sampling reach

Habitat Parameter	Condition Category: Optimal	Suboptimal	Marginal	Poor
6. Channel Alteration	Channelization or dredging absent or minimal; stream with normal pattern.	Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present.	Channelization may be extensive; embankments or shoring structures present on both banks, and 40 to 80% of stream reach channelized and disrupted.	Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely.
SCORE 11	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
7. Frequency of Riffles (or bends)	Occurrence of riffles relatively frequent; ratio of distance between riffles divided by width of the stream <7:1 (generally 5 to 7); variety of habitat is key. In streams where riffles are continuous, placement of boulders or other large, natural obstruction is important.	Occurrence of riffles infrequent; distance between riffles divided by the width of the stream is between 7 to 15.	Occasional riffle or bend; bottom contours provide some habitat; distance between riffles divided by the width of the stream is between 15 to 25.	Generally all flat water or shallow riffles; poor habitat; distance between riffles divided by the width of the stream is a ratio of >25.
SCORE 16	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
8. Bank Stability (score each bank) Note: determine left or right side by facing downstream.	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.
SCORE 9 (LB)	Left Bank 10 (9)	8 7 6	5 4 3	2 1 0
SCORE 8 (RB)	Right Bank 10 (8)	8 7 6	5 4 3	2 1 0
9. Vegetative Protection (score each bank)	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
SCORE 10 (LB)	Left Bank (10) 9	8 7 6	5 4 3	2 1 0
SCORE 10 (RB)	Right Bank (10) 9	8 7 6	5 4 3	2 1 0
10. Riparian Vegetative Zone Width (score each bank riparian zone)	Width of riparian zone >18 meters; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone.	Width of riparian zone 12-18 meters; human activities have impacted zone only minimally.	Width of riparian zone 6-12 meters; human activities have impacted zone a great deal.	Width of riparian zone <6 meters: little or no riparian vegetation due to human activities.
SCORE 7 (LB)	Left Bank 10 9	8 (7) 6	5 4 3	2 1 0
SCORE 9 (RB)	Right Bank 10 (9)	8 7 6	5 4 3	2 1 0

Total Score 107

Upper Animas Assessment and Measurement Endpoints

- *Maintain a stable and healthy benthic invertebrate community.*
  - *Hazard Quotient (effect and no effect)*
  - *Toxicity Tests*
  - *Community Survey*
- *Maintain a stable and healthy fish community.*
  - *Hazard Quotient*
  - *Toxicity Tests*
  - *Community Survey*
- *Maintain stable and healthy insectivorous, omnivorous, piscivorous bird populations.*
  - *Hazard Quotient-Food Chain modelling*
- *Maintain stable and healthy herbivorous mammal populations*
  - *Hazard Quotient-Food Chain modelling*

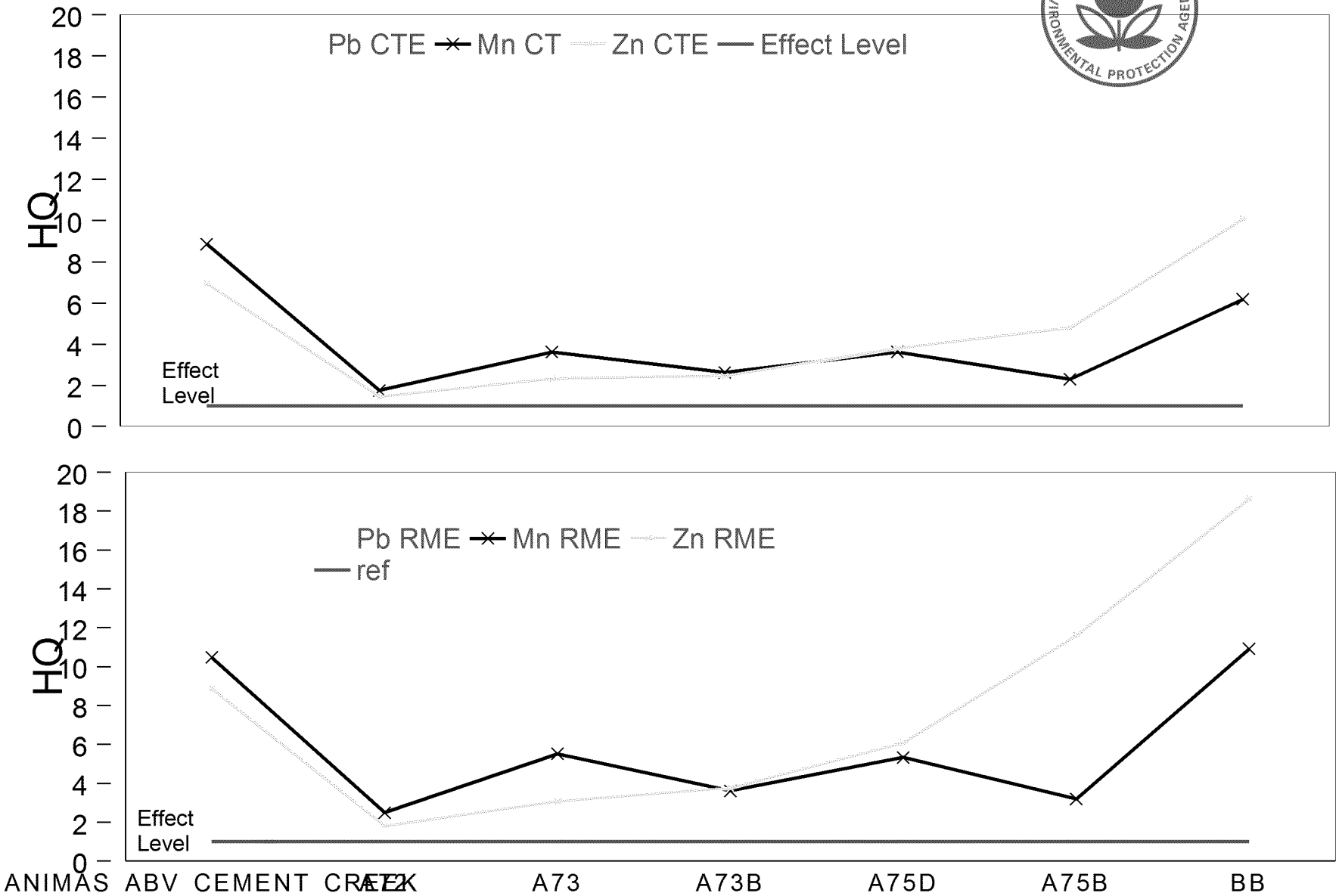
Results

- *Maintain a stable and healthy benthic invertebrate community.*
  - *Hazard Quotient (effect and no effect)*
    - *Sediment and Porewater*
  - *Toxicity Tests*
  - *Community Survey*
- *Maintain a stable and healthy fish community.*
  - *Hazard Quotient*
  - *Toxicity Test*
  - *Community Survey*

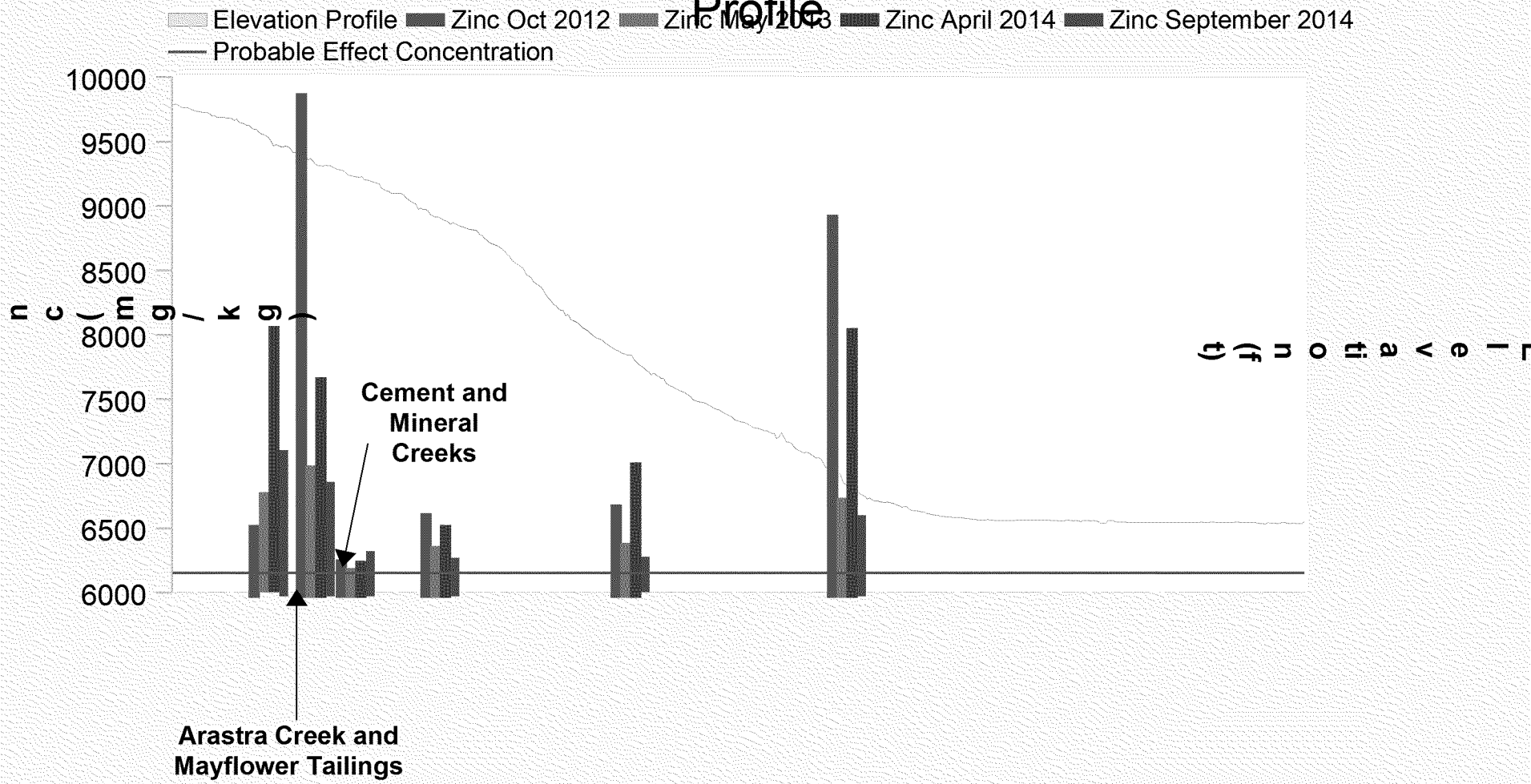
Sediment Data Evaluation

- Organized by river reach (EU)
- Not enough data to organize by flow regime
- No effect and effect benchmarks
- Sediment concentrations evaluated as RME and CTE.

CTE and RME Sediment Effect HQs Results



Zinc Sediment Concentrations and Animas River Elevation Profile



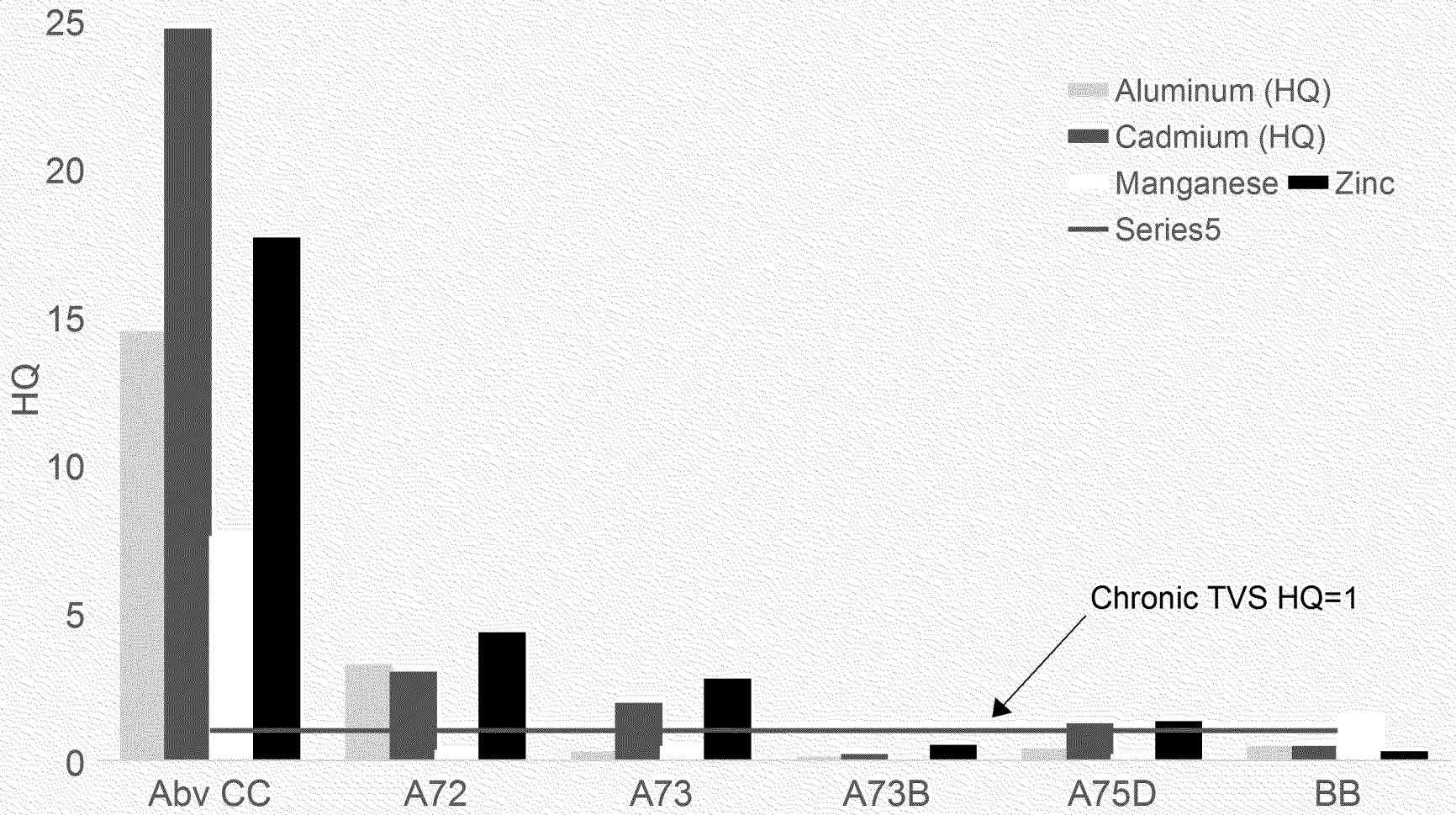
Sediment HQ Conclusions

- Primary Risk Drivers to benthic community
  - Lead, Manganese and Zinc
  - Elevated risk in all reaches of the mainstem
- Secondary Risk Drivers
  - Cadmium and Copper
  - Varies by reach
- Some metals increase thru canyon
- Bulk metals concentrations highly variable

Pore Water Data Evaluation

- Organized by river reach (EU)
- Not enough data to organize by flow regime
  - 11 samples upstream, 1 or 2 samples/station downstream of Cement Creek
- Hardness evaluated at mean and 95% LCL
- Compared to chronic water quality standards (TVS)
  - Aluminum, pH, dissolved

Sediment Porewater HQs
Average Concentration and Average Hardness



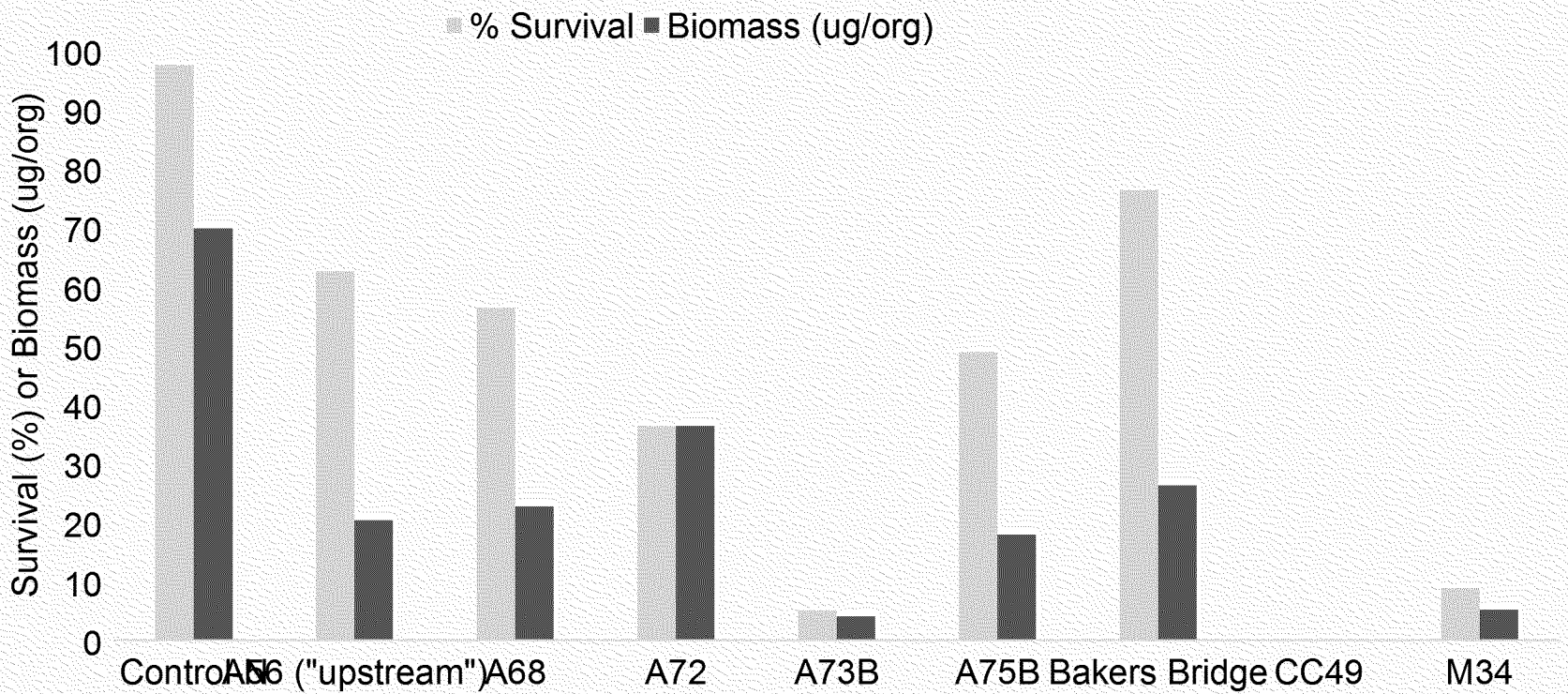
Porewater HQ Conclusions

- Risks generally low to moderate
- Risk drivers Al, Cd, Mn and Zn
  - Variable by location
- Upstream risks are substantially higher
  - Driven largely by A61
- Uncertainties
  - Data set is small
  - Aluminum results uncertain (dissolved, no pH)

Results

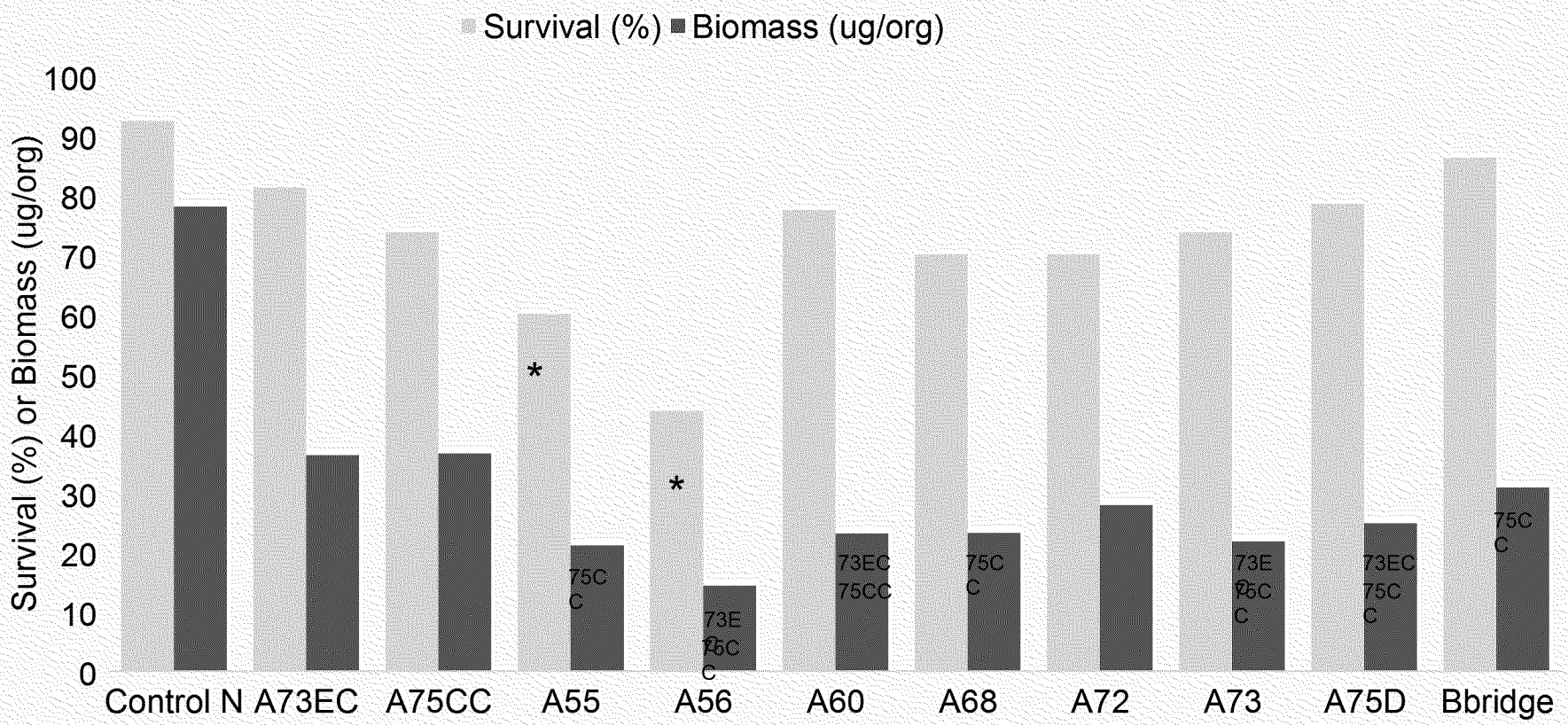
- *Maintain a stable and healthy benthic invertebrate community.*
  - *Hazard Quotient (effect and no effect)*
    - *Sediment and Porewater*
  - *Toxicity Tests*
  - *Community Survey*
- *Maintain a stable and healthy fish community.*
  - *Hazard Quotient*
  - *Toxicity Test*
  - *Community Survey*

2012 Sediment Toxicity Test Results



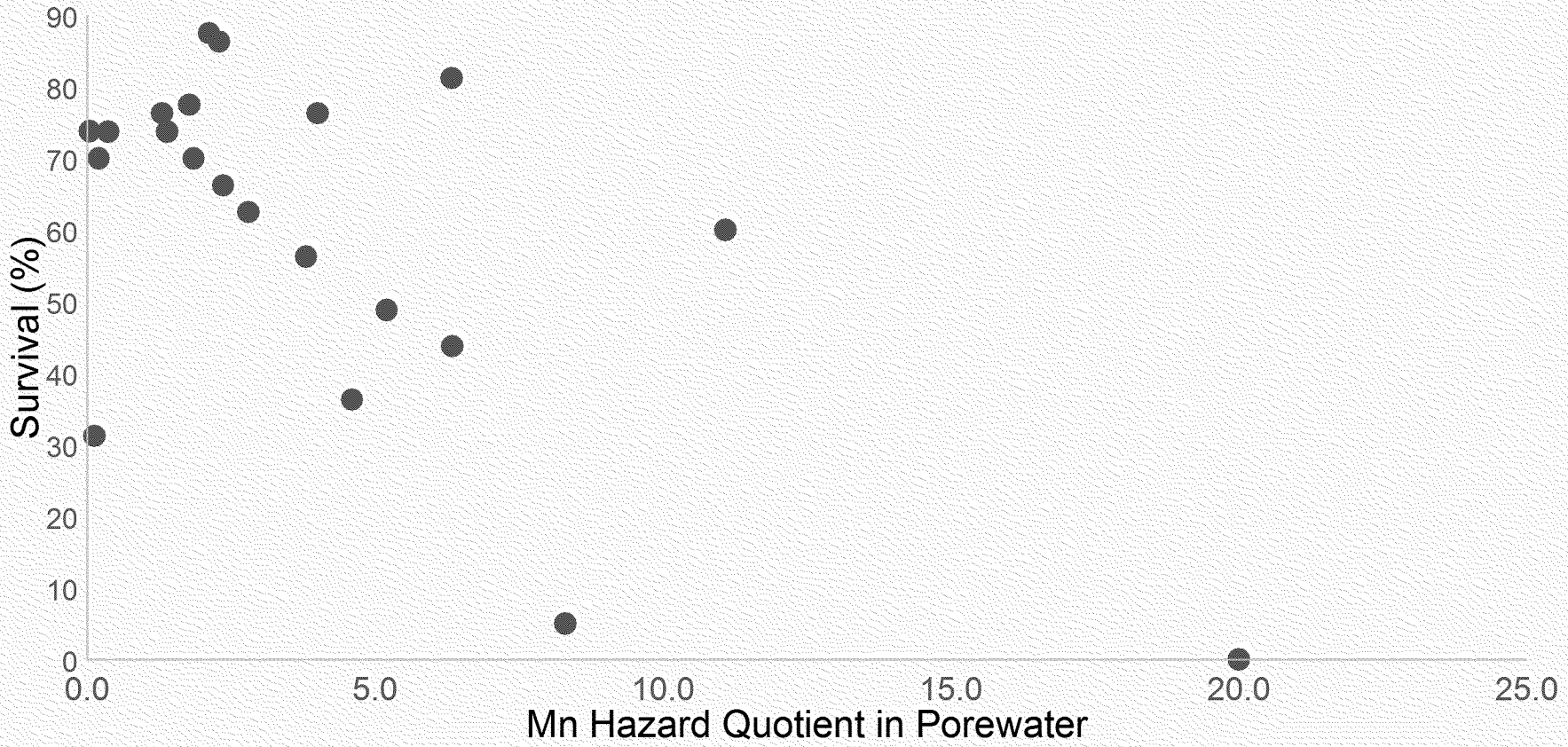
All locations statistically different from Control-N

2014 Sediment Toxicity Test Results



*statistically different from Control-N for Survival results. All Biomass results statistically less than Control-N.
73EC-statistically different than station A73EC
75CC- statistically different that station A75CC

Survival vs Mn HQs in Porewater ?



Sediment Toxicity Test Conclusions

- Survival results variable between 2012 and 2014
  - 2012:
    - All locations showed low survival and biomass compared to lab control.
  - 2014:
    - Upstream locations had low survival compared to lab control.
    - Most locations had low biomass compared to Elk and Cascade creek locations
    - All locations had low biomass compared to lab control
- Responses not obviously correlated to bulk metals
- Responses *suggest* Mn playing a role in toxicity

Results

- *Maintain a stable and healthy benthic invertebrate community.*
  - *Hazard Quotient (effect and no effect)*
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- *Maintain a stable and healthy fish community.*
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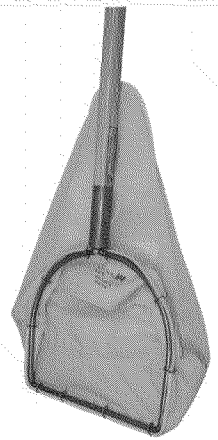
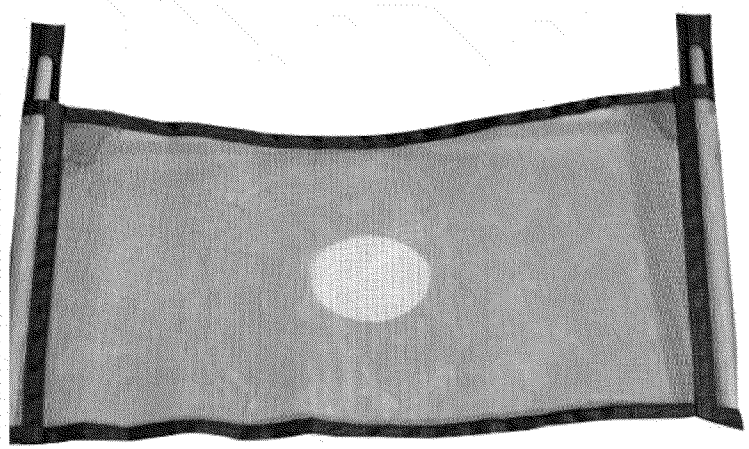
Benthic Community Survey Methods

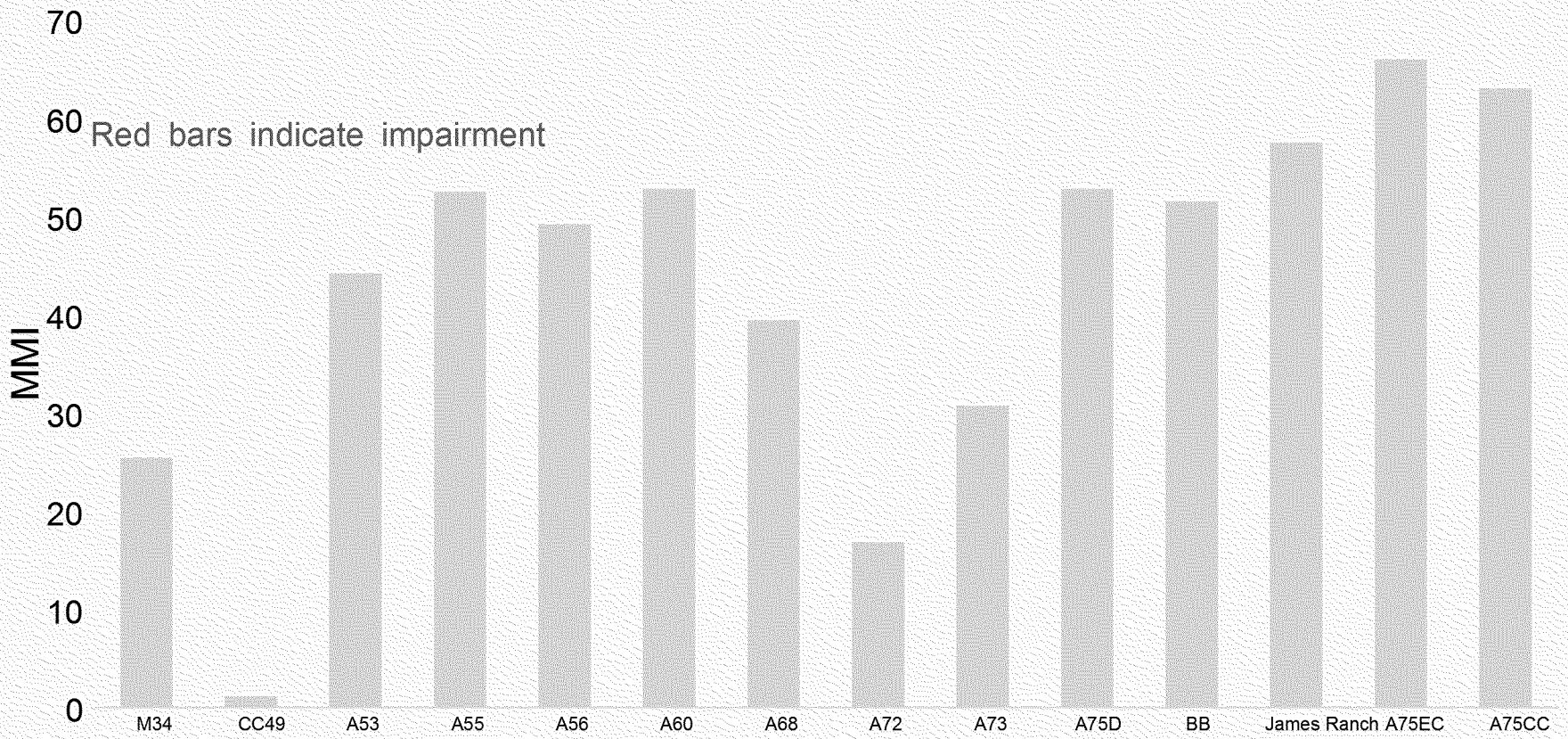




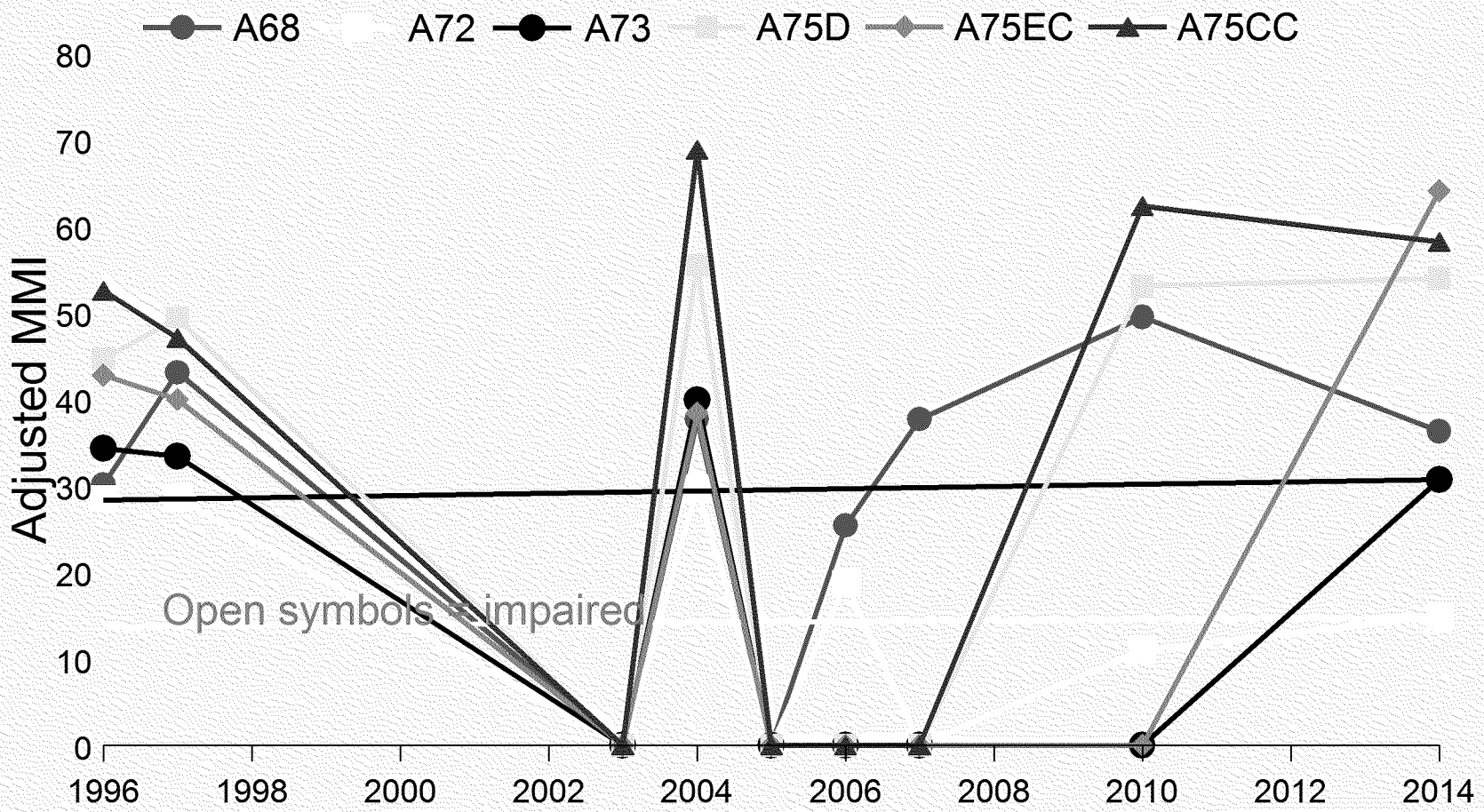
Historic Data Uncertainty

- Multiple methods listed in the datasheets and reports
- CO Multi-Metric Index (MMI) recalibrated
  - Comprised of different metrics
  - Different identification requirements
  - Different classification of organisms
- Comparisons with historic data
  - 2014 calculated to match historic data
  - Historic data reclassified to match current requirements where possible
- Consider as qualitative estimates

2014 MMI


70
60
50
40
30
20
10
0
MMI
Red bars indicate impairment
M34
CC49
A53
A55
A56
A60
A68
A72
A73
A75D
BB
James Ranch
A75EC
A75CC

Adjusted MMI



Benthic Community Survey Conclusions

- 2014 results scored as impaired at several locations.
  - Impairment greatest below Cement Creek
  - Recovery evident downstream
  - Upstream not consistently or severely impaired
- Historic trends
  - Results are uncertain
  - A72,A73 consistently impaired
  - A68 inconsistently and moderately impaired

Benthic Invertebrate Risk Conclusions

- Evidence shows strong likelihood of risk to invertebrates in the Animas River.
- Severity decreases downstream.
- Chemistry variable by location.
- Effects not obviously attributable to single metal.
- Chemistry vs Effect not consistent across lines of evidence

Results

- *Maintain a stable and healthy benthic invertebrate community.*
  - *Hazard Quotient (effect and no effect)*
    - *Sediment and Porewater*
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- *Maintain a stable and healthy fish community.*
  - *Hazard Quotient*
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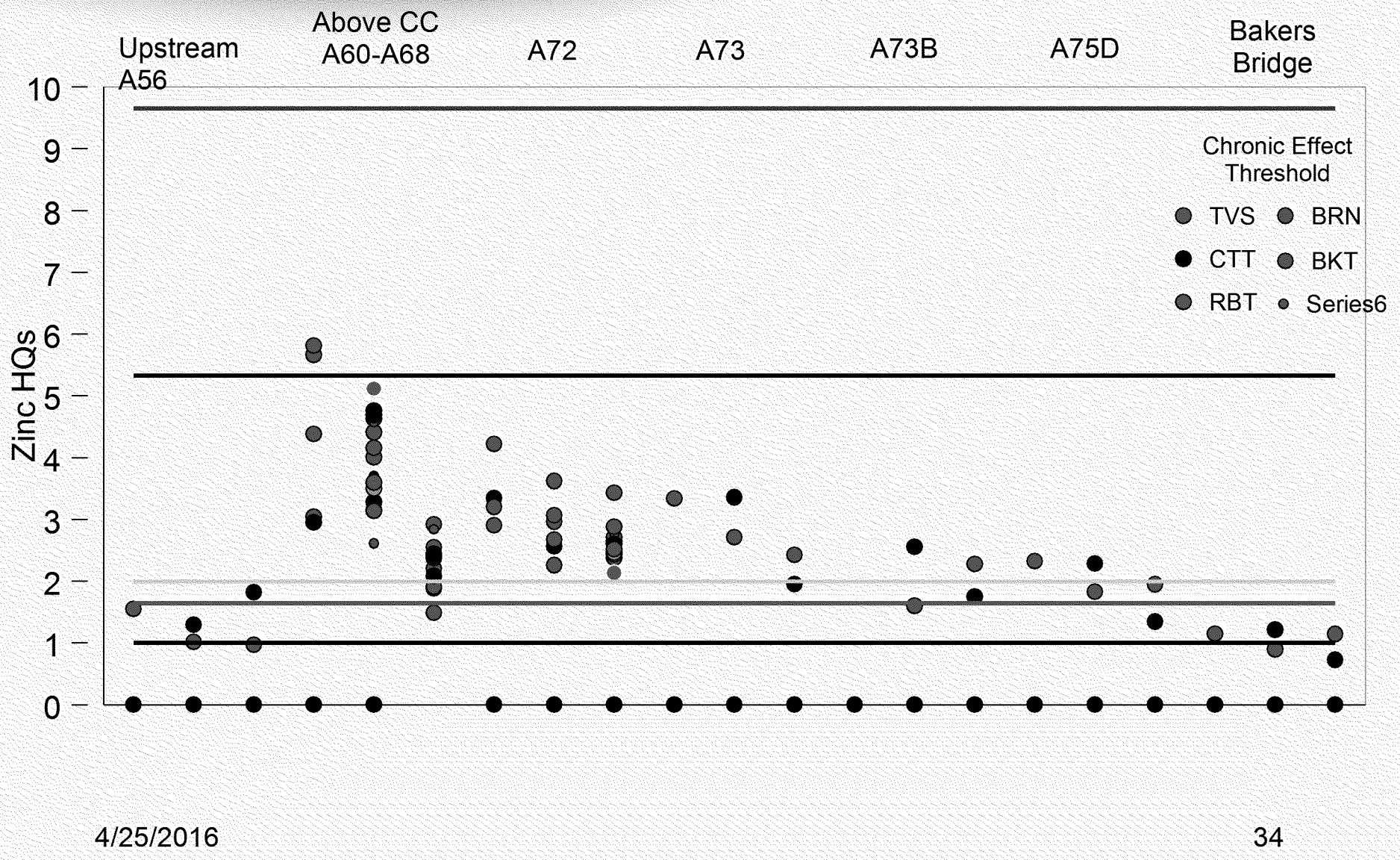
  - *Community Survey*

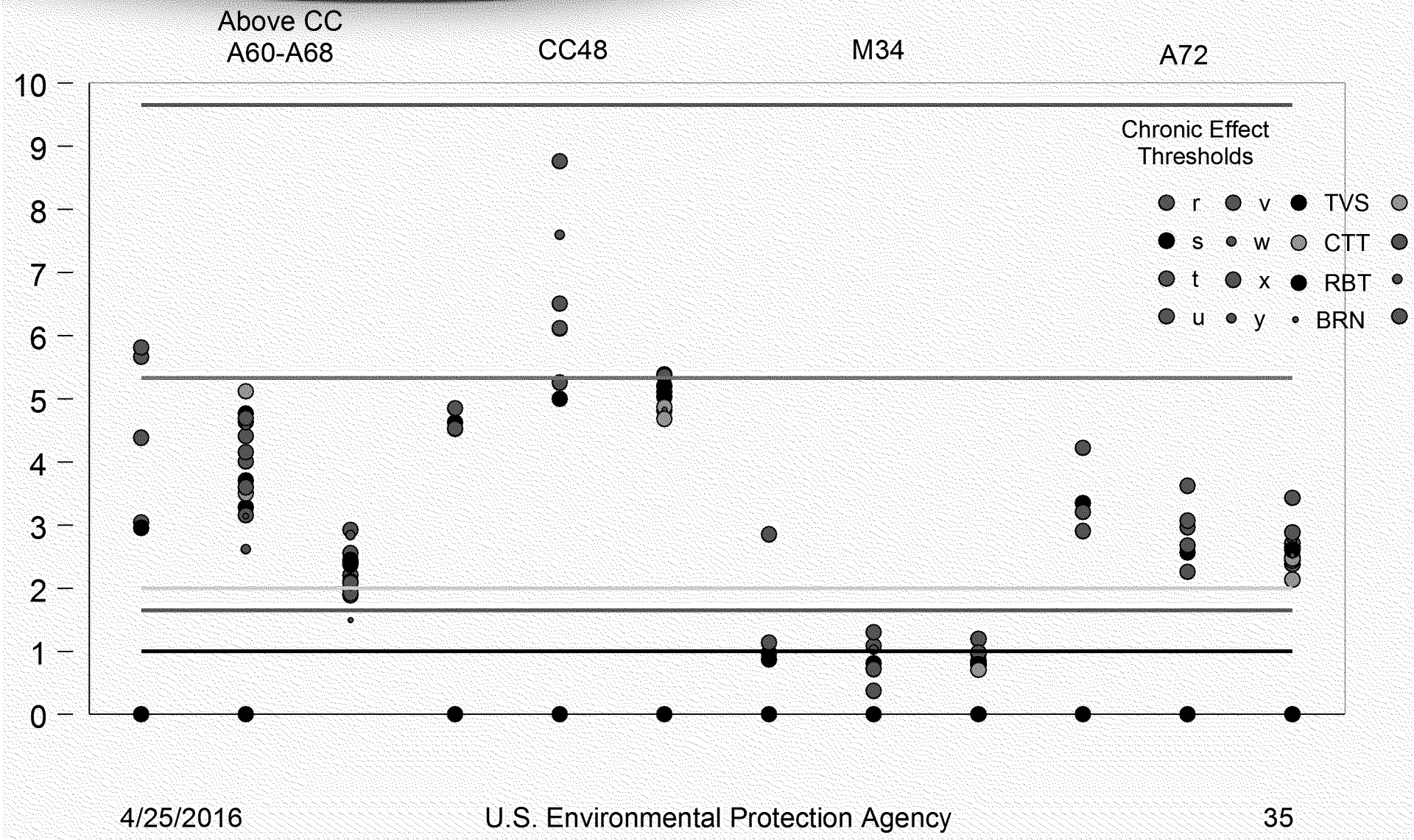
Surface Water HQ Assessment

- Two approaches
  1) Averaging over a reach *and* flow regime
     - Metals concentrations-95%UCL (or maximum) and mean
     - Hardness-95%LCL (or minimum) and mean
     - RME and CTE for both mean and low hardness
  2) Scatter plot across reach *and* flow regime
     - HQs from paired hardness and metal concentration
     - Benchmark normalized to sample hardness
- Flow regime (where data is adequate)
  - Pre-runoff (Feb-April), Runoff (May-June), Post-runoff (July-Nov)

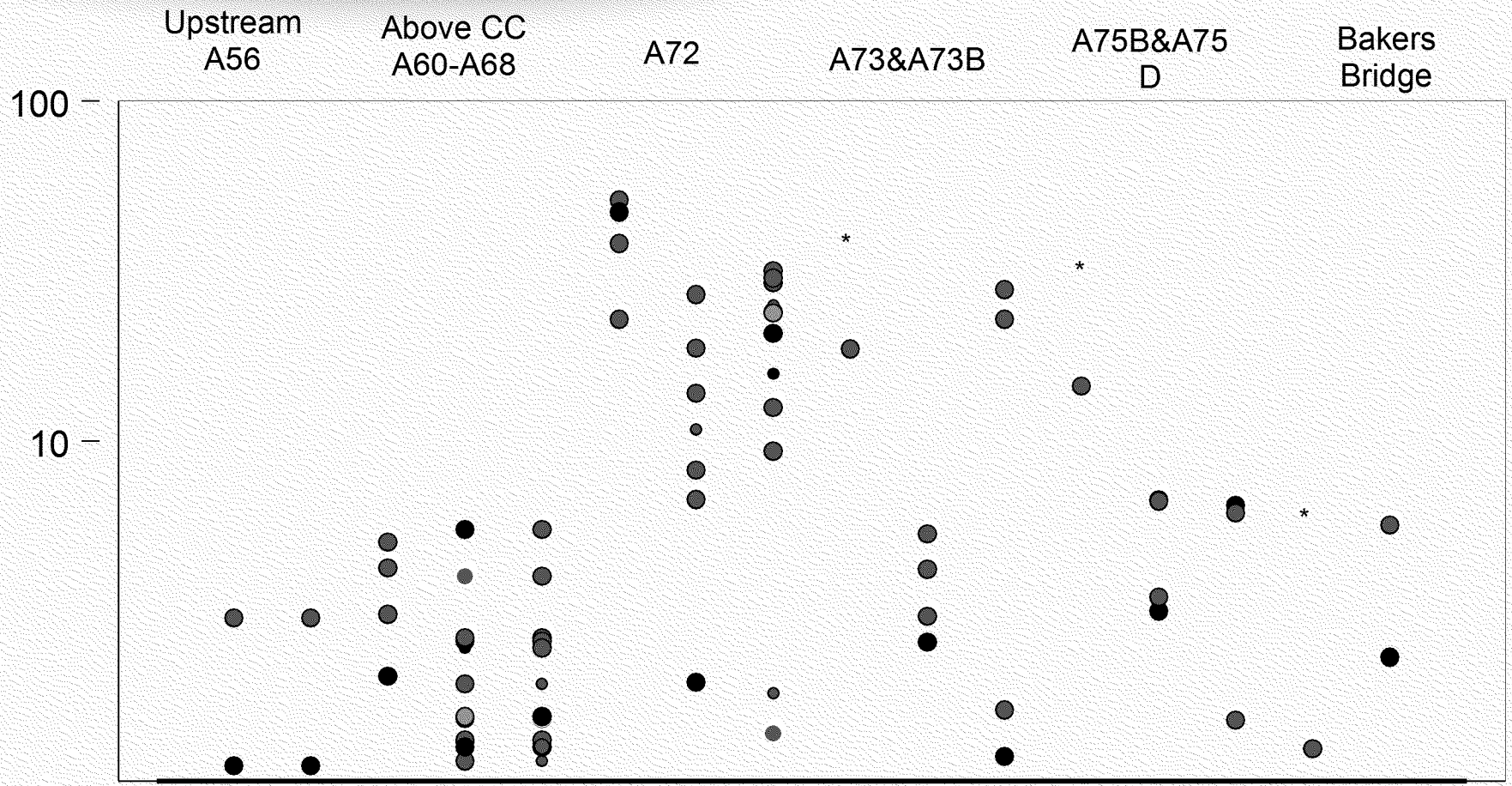
Zinc Surface Water HQs



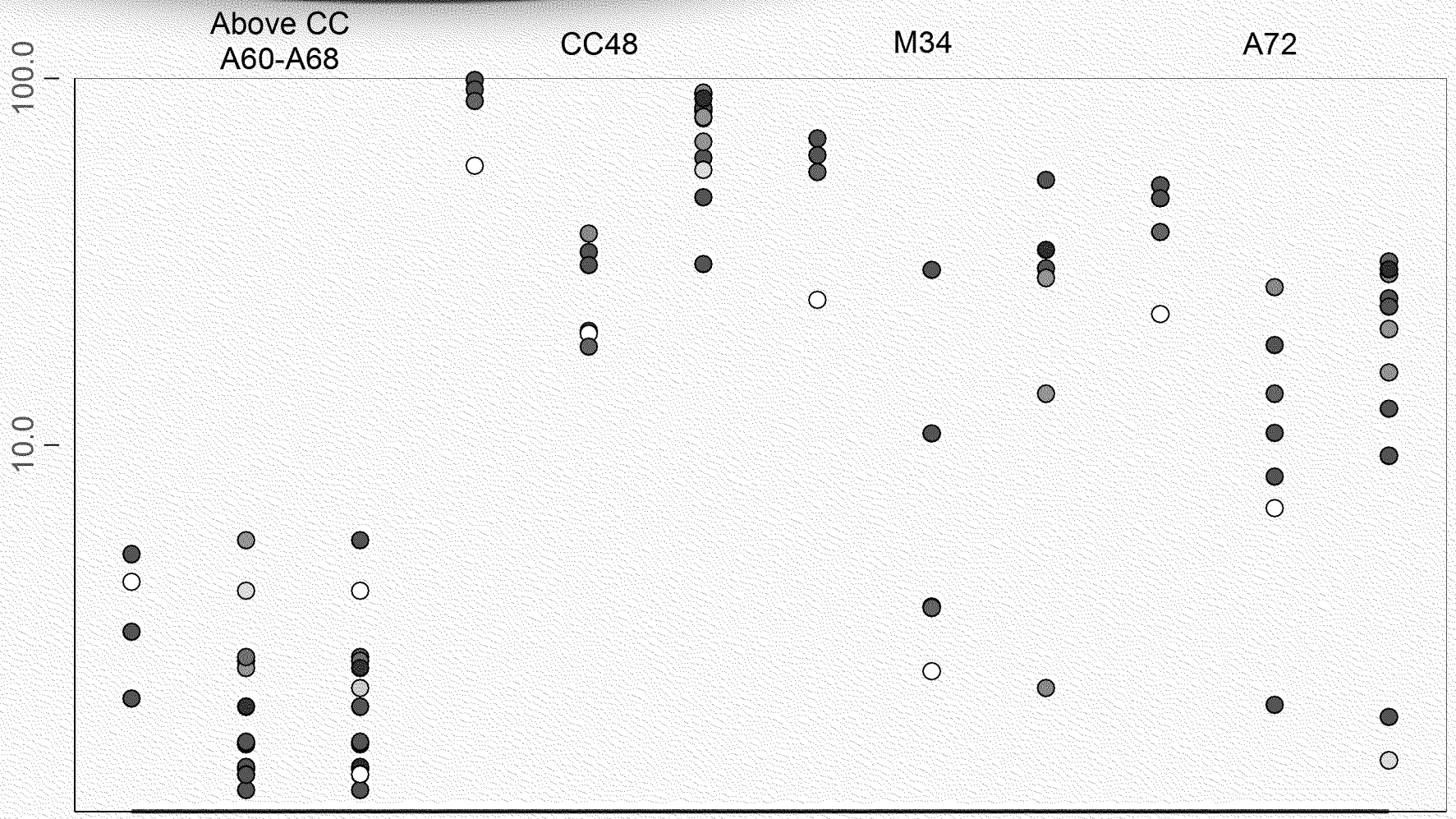
Zinc Surface Water HQs



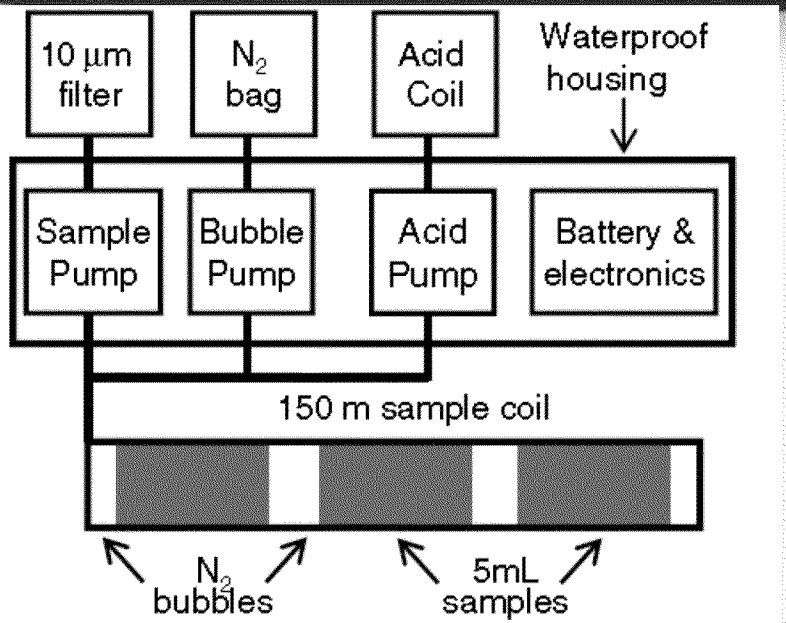
Aluminum Surface Water HQs

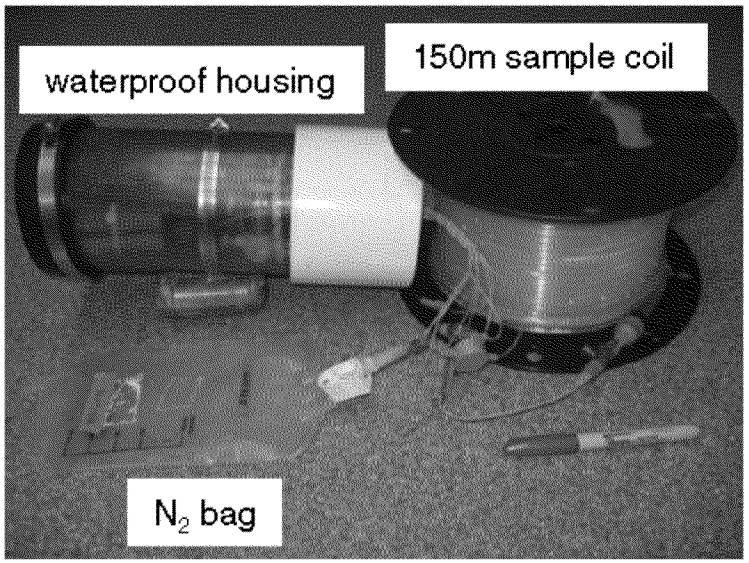


Aluminum Surface Water HQs



Mini-Sipper





- Thomas Chapin, USGS

  MiniSipper: A new in situ water sampler for high-resolution, long-duration acid mine drainage monitoring.

Science of the Total Environment 439 (2012) 343–353

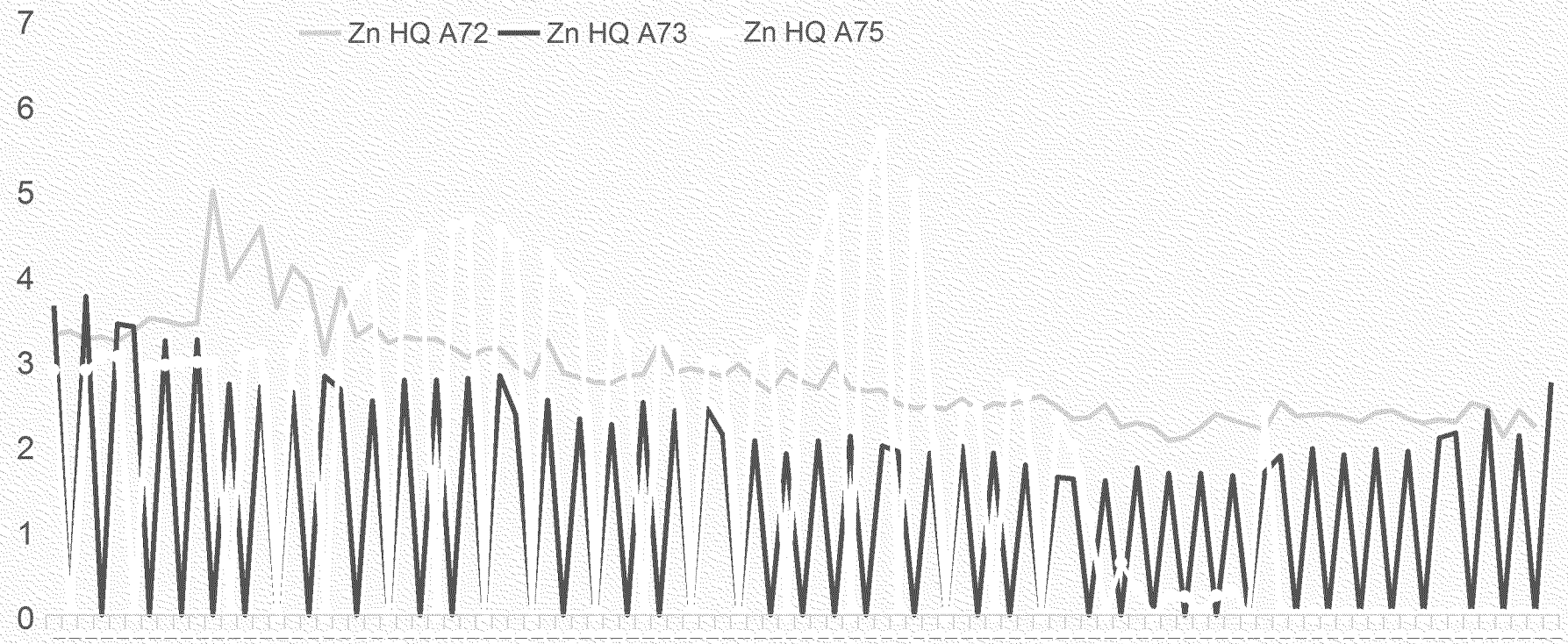
Mini-Sipper Data

- 2013 (mid April-July)
  - A72, A73, A75D
- 2014 (mid April-July)
  - A55, A56, A68, A72, A73, A75D, BB
- 2015 (mid Nov-mid April)
  - LA2, A45, A55, A68, A72, BB

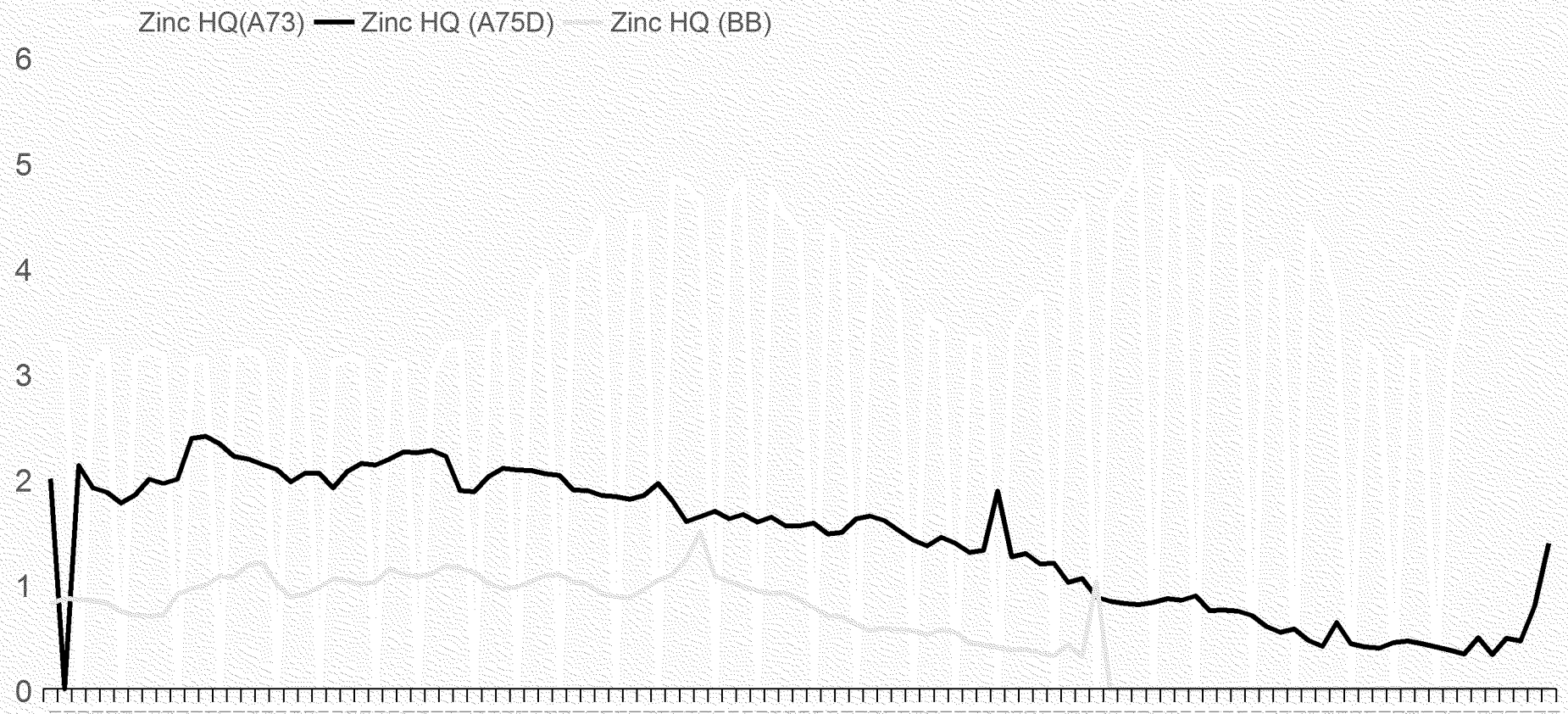
Use of Mini-Sipper data in BERA

- Several limitations
  - 10um filter
  - Limited QA
  - Subject to smearing
- Screening level data
- Consistent with grab samples trends?

2013 Mini-Sipper data (Zn HQ)



2014 Mini-Sipper data (Zn HQ)



Surface Water HQs Conclusions

- Animas Upstream of Cement Creek
  - Elevated risk most flow regimes
  - Risk driven by Al, Cd and Zn
  - Seasonally (pre-runoff) significant risk from primarily Zn
- Animas downstream of Cement Creek
  - High HQs during almost all flow regimes
  - Risk driven by Aluminum and to a lesser degree by Zinc
  - Effects expected down to at least Bakers Bridge
  - Effects lessen downstream
- Mini-sipper results are consistent with grab samples.

Results

- *Maintain a stable and healthy benthic invertebrate community.*
  - *Hazard Quotient (effect and no effect)*
    - *Sediment and Porewater*
  - *Toxicity Tests*
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- *Maintain a stable and healthy fish community.*
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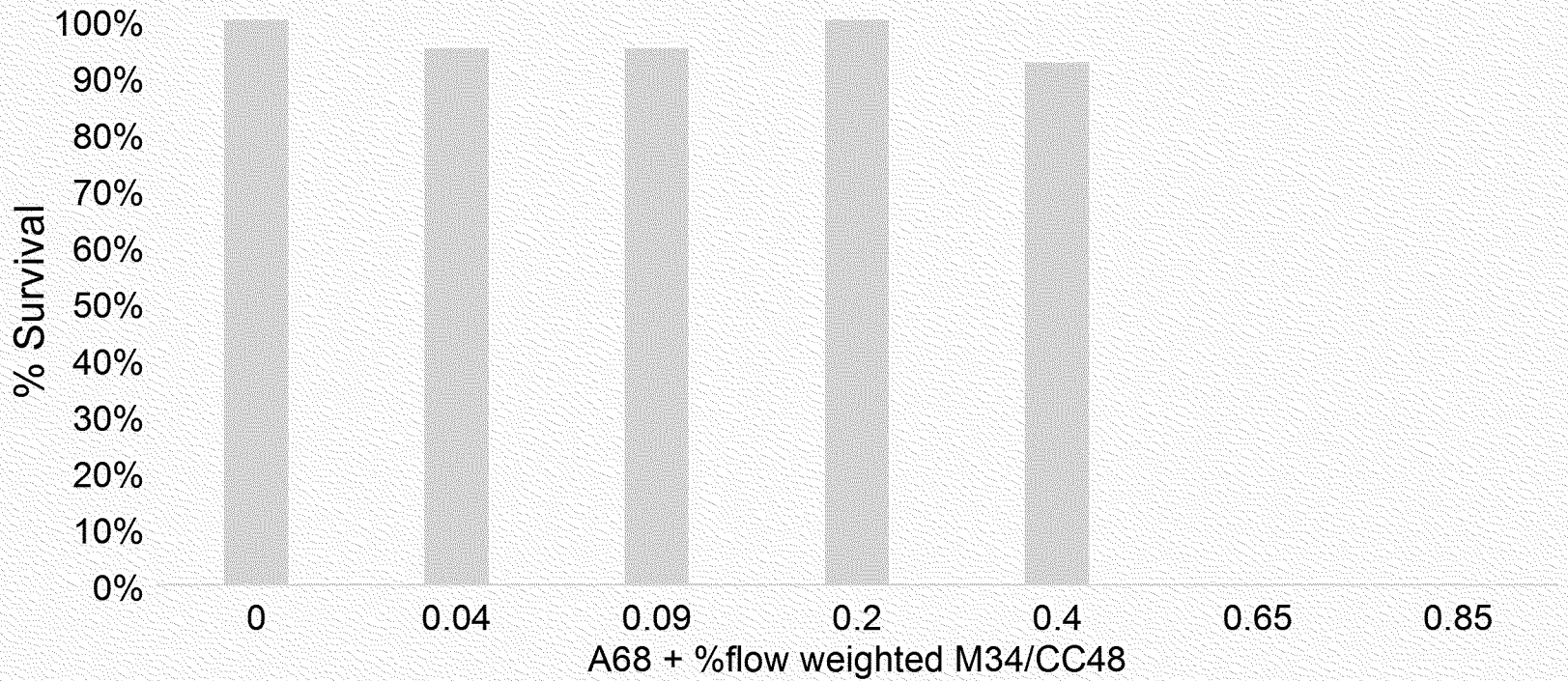
  - *Community Survey*

Toxicity Tests

- Test Dates
  - Oct 2012, Nov 2012 and April 2013
- Dilution Series
  - Establish dose response
- Profile Tests
  - Test individual stations
- Rainbow trout
- 96hr-standard methods

Example SW Toxicity Test Results

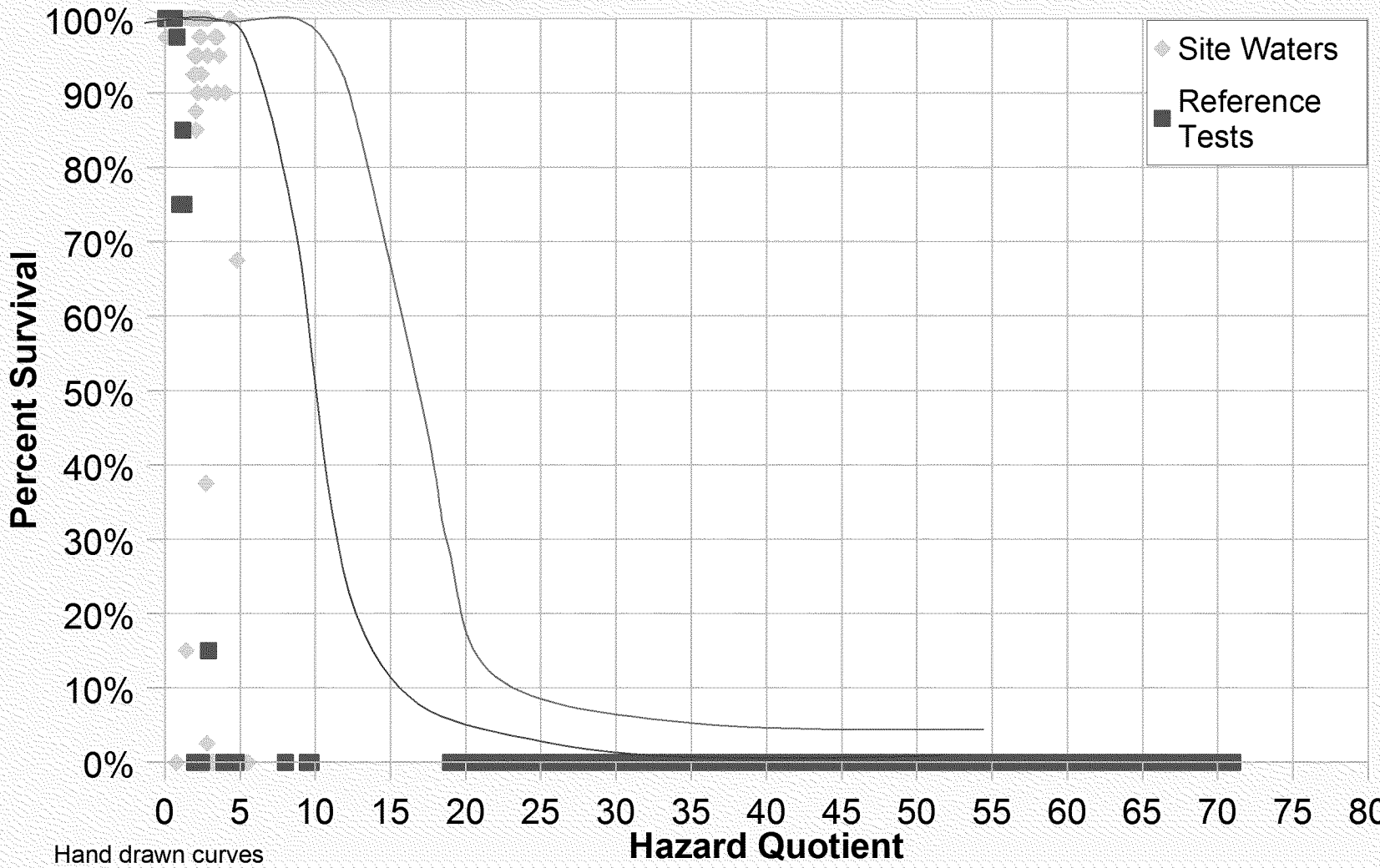


SW Toxicity Test Results

- Acute toxicity observed
  - M34, CC48, A72 (~0% survival)
- Acute toxicity observed seasonally
  - A68 (67.5% survival)
- No acute toxicity observed downstream of A72
  - A73, A73B, A75B, Bakers Bridge

Trout Survival vs Zinc HQs

pooled toxicity test data



Hand drawn curves

Results

- *Maintain a stable and healthy benthic invertebrate community.*
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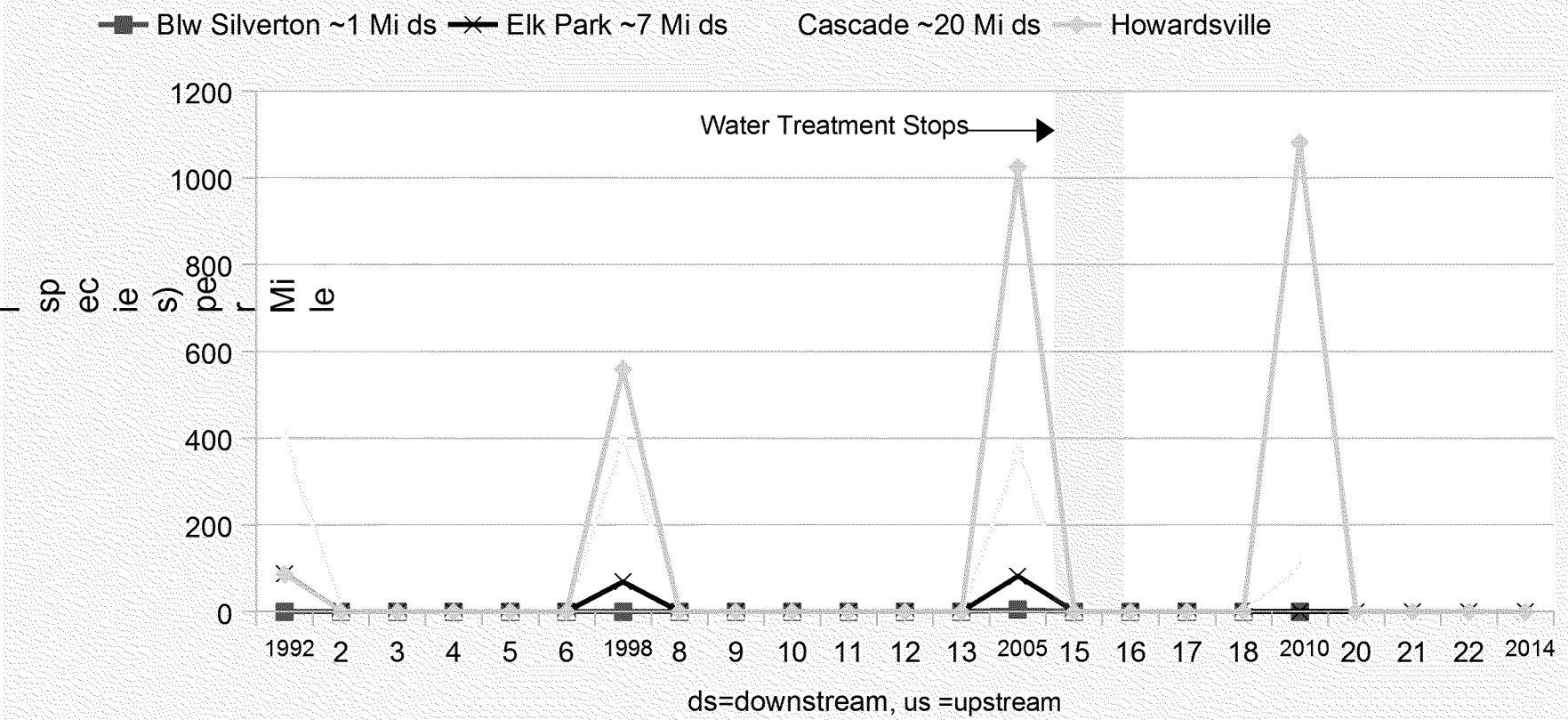
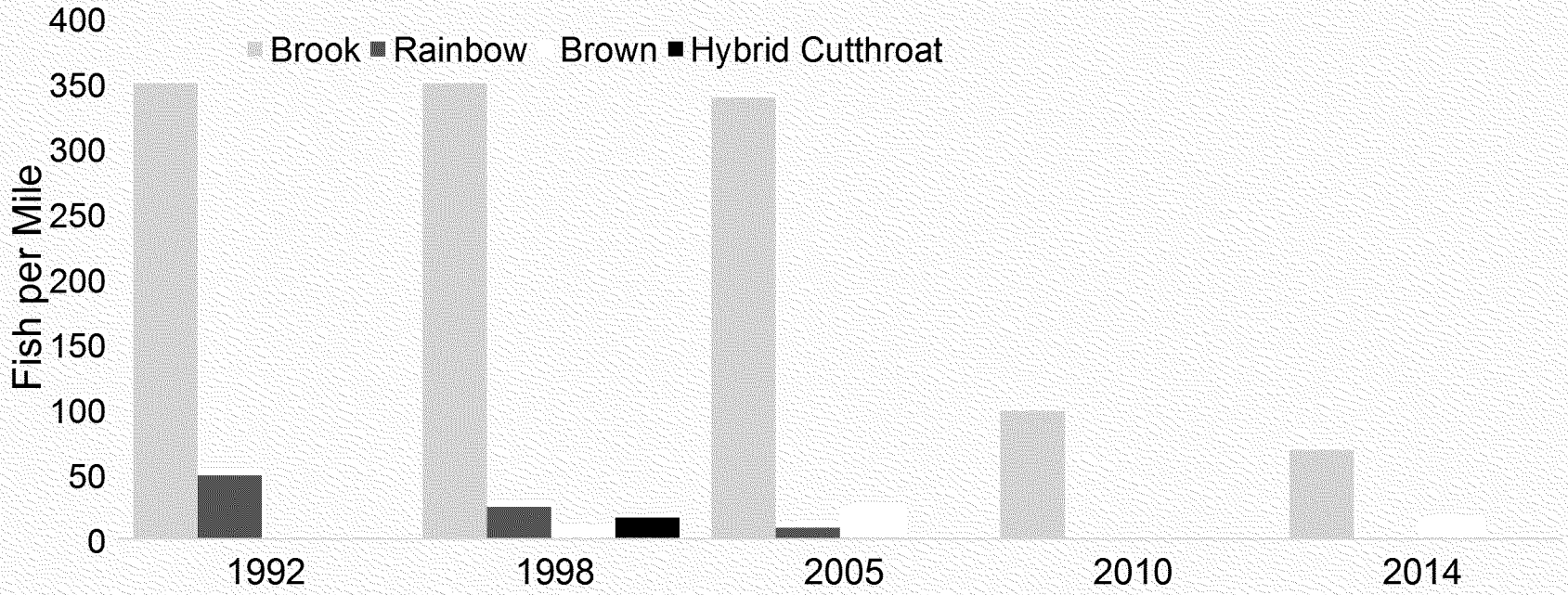
Fish Community Survey Results

Colorado Parks and Wildlife Data



2014 Fish Survey Results

Animas at Cascade Creek (Tefts Spur)

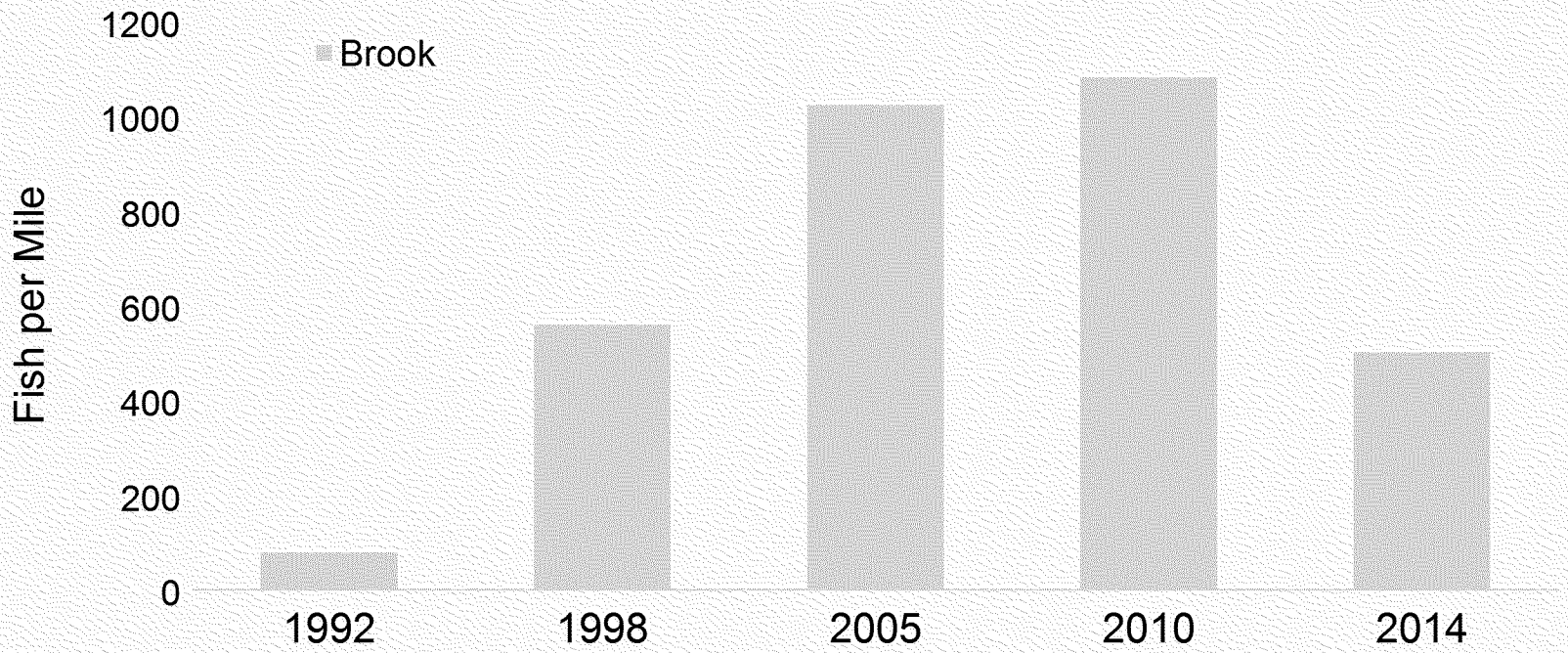


2014

- 9 brook trout and 2 brown trout (~2.4 lbs/acre)
- 1 juvenile and 10 adults
- Brook trout Wr = 96%, brown trout Wr = 100%

2014 Fish Survey Results

Animas at Howardsville above Cunningham Creek



2014

- 162 brook (~17 lbs/acre)
- Multiple age classes
- Brook trout Wr = 102%, up from 85% in 2010

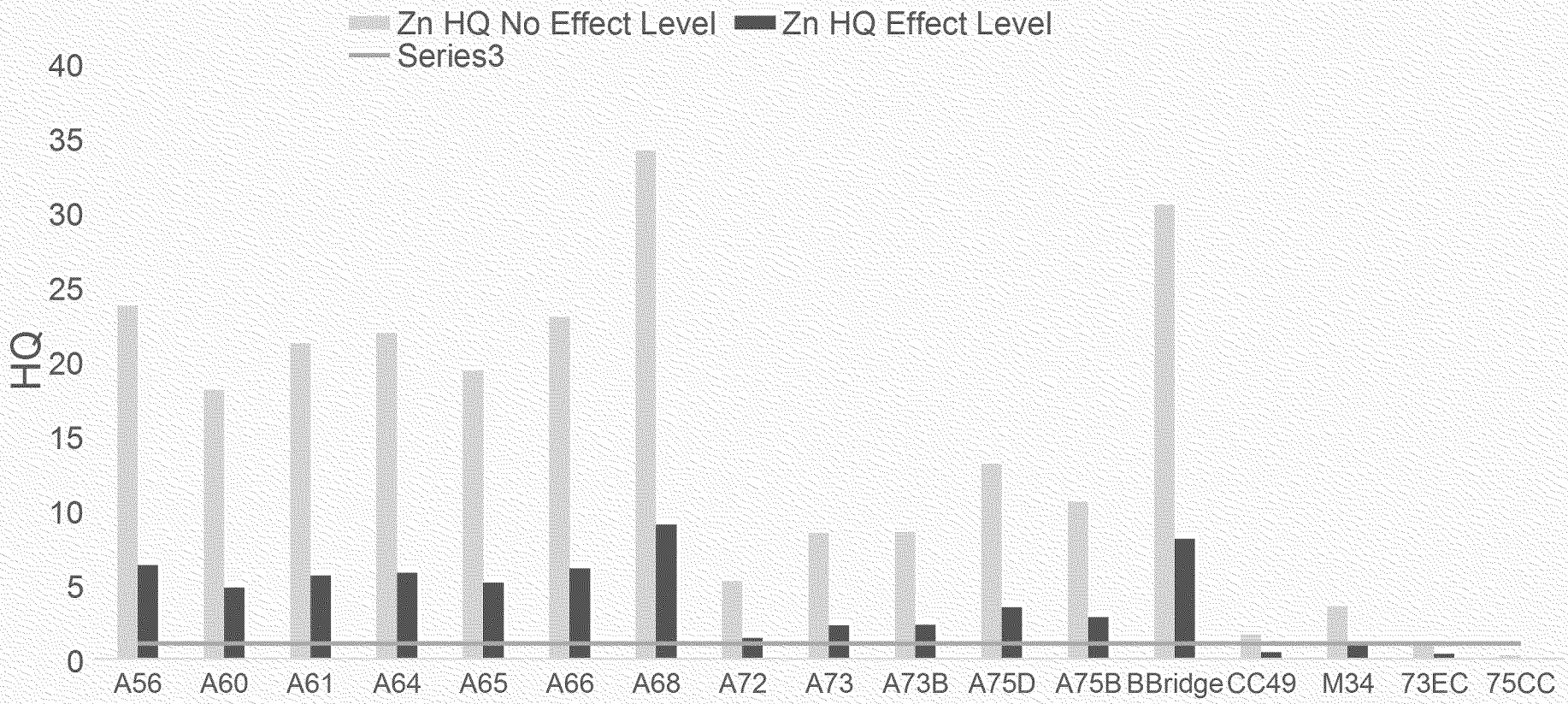
Fish Survey Results

- 2014 Survey Results at Cascade Creek
  - Fishery significantly impaired
  - 30% reduction from 2010
  - Poor age class structure, low body condition
  - 2 Brown trout present
- 2014 Survey Results above Howardsville
  - Less fish than 2010 but biomass is about the same
  - Good body condition
- Time trend
  - Animas fishery below Cement Creek has dramatically declined since 2005

BERA Conclusions

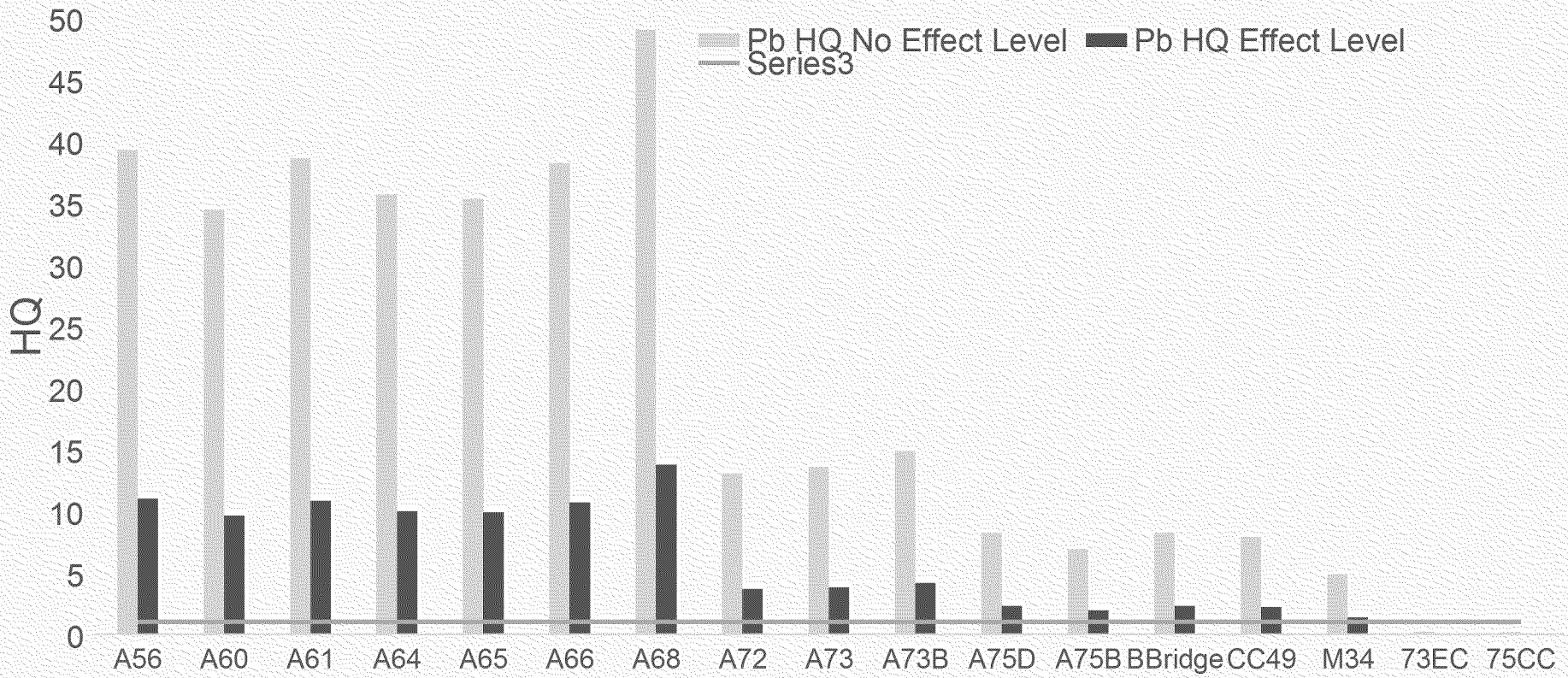
- Aquatic community is impaired from Cement Creek to Bakers Bridge.
  - Surface water and sediment
  - Aluminum, zinc, cadmium, manganese, pH
- Elevated risk upstream
  - Surface water and sediment
  - Seasonally influenced
  - Aluminum, zinc and cadmium
- Risks to wildlife using Animas River is low

Zinc Hazard Quotients in Sediments*



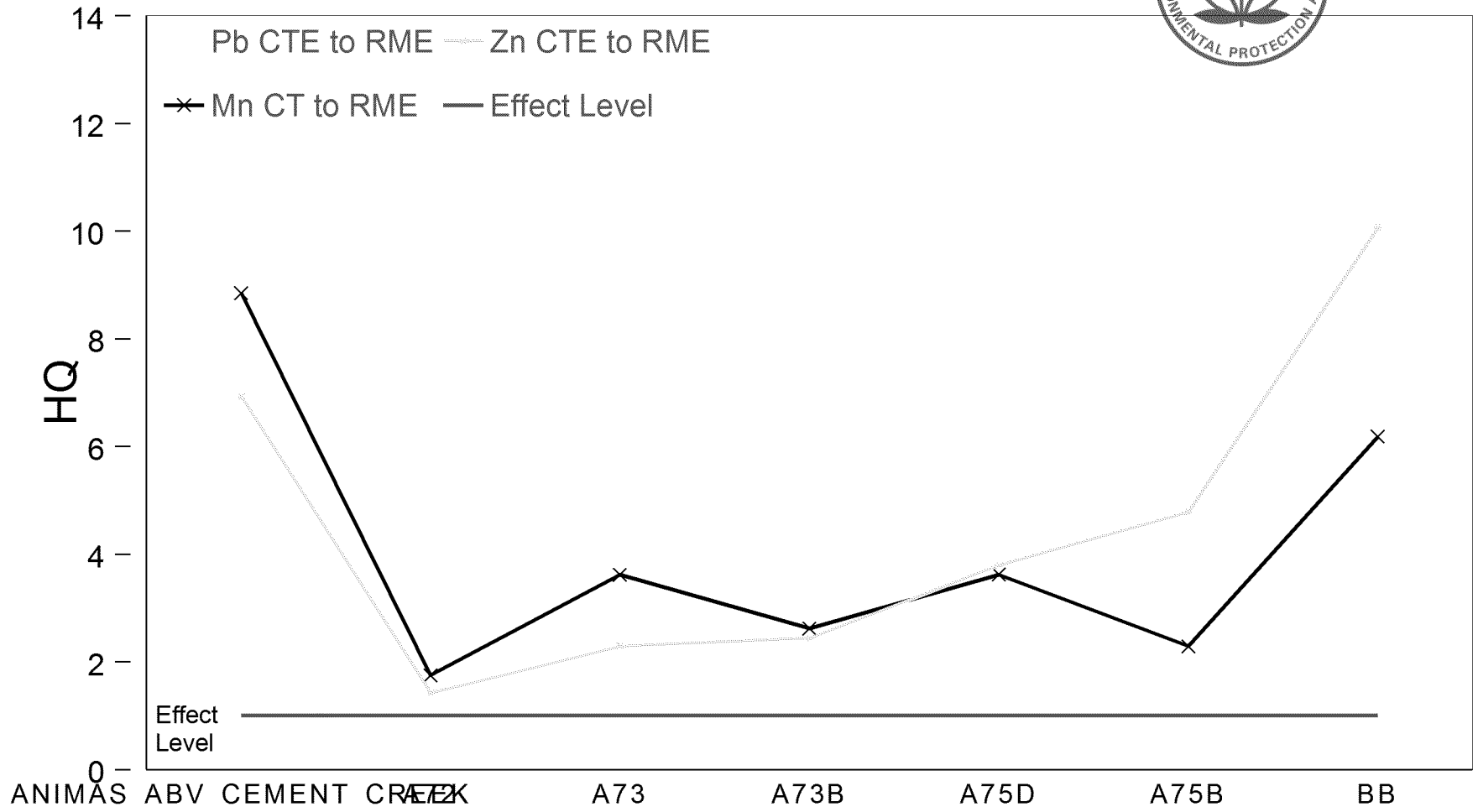
*geometric means. High seasonal variability at some locations.

Zinc Hazard Quotients in Sediments*

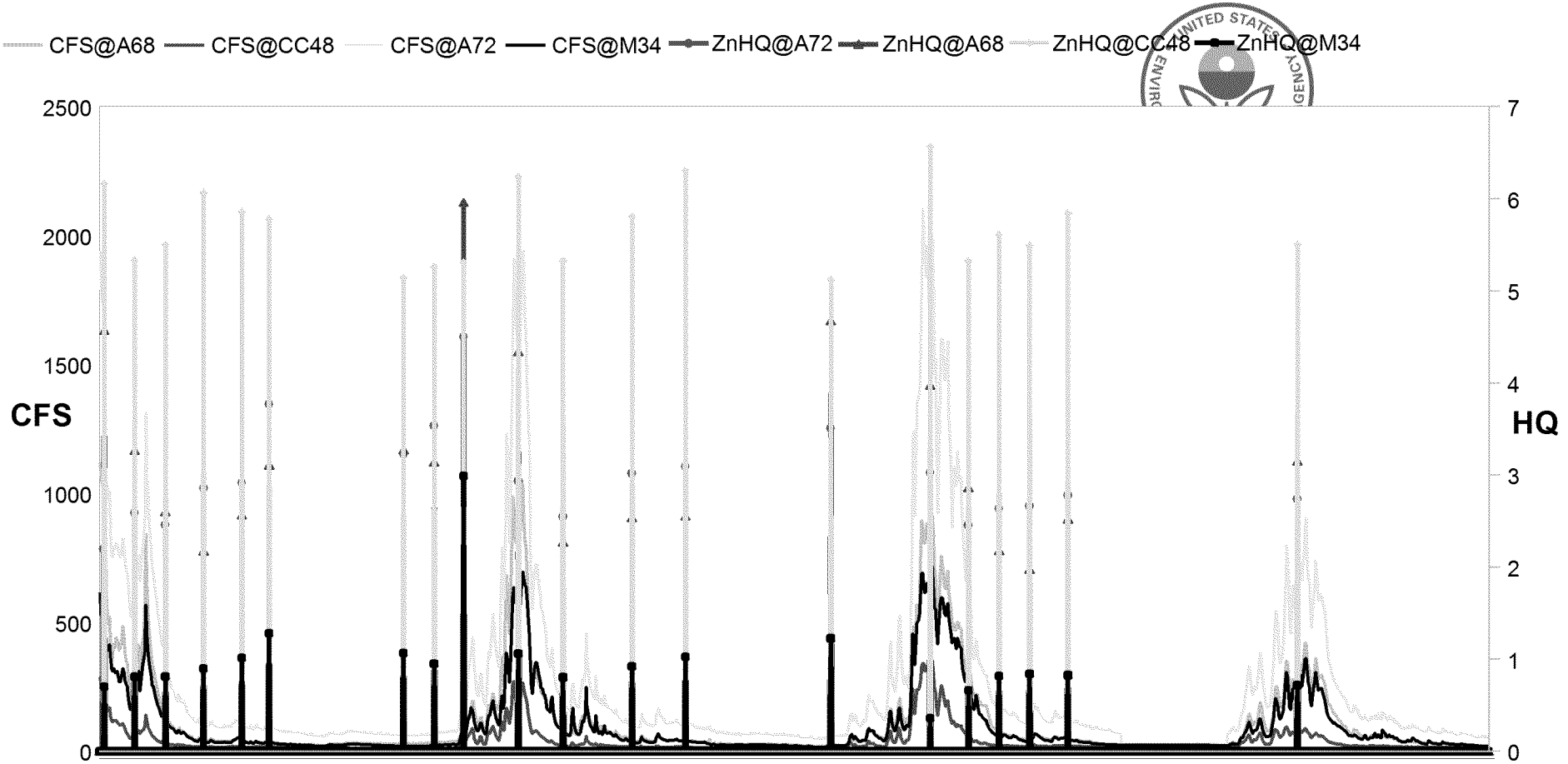


*geometric means. High seasonal variability at some locations.

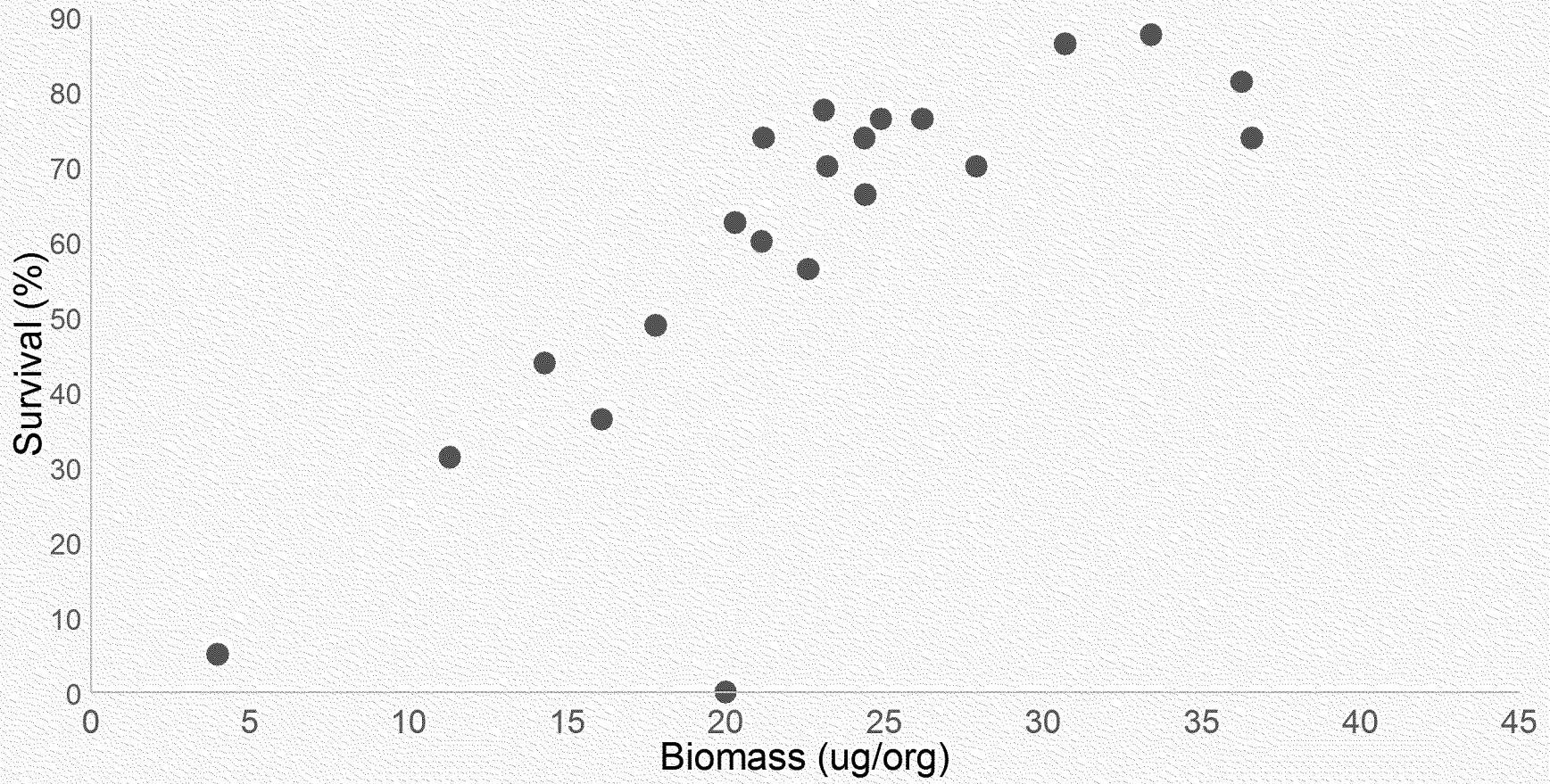
CTE/RME Range of Sediment HQs



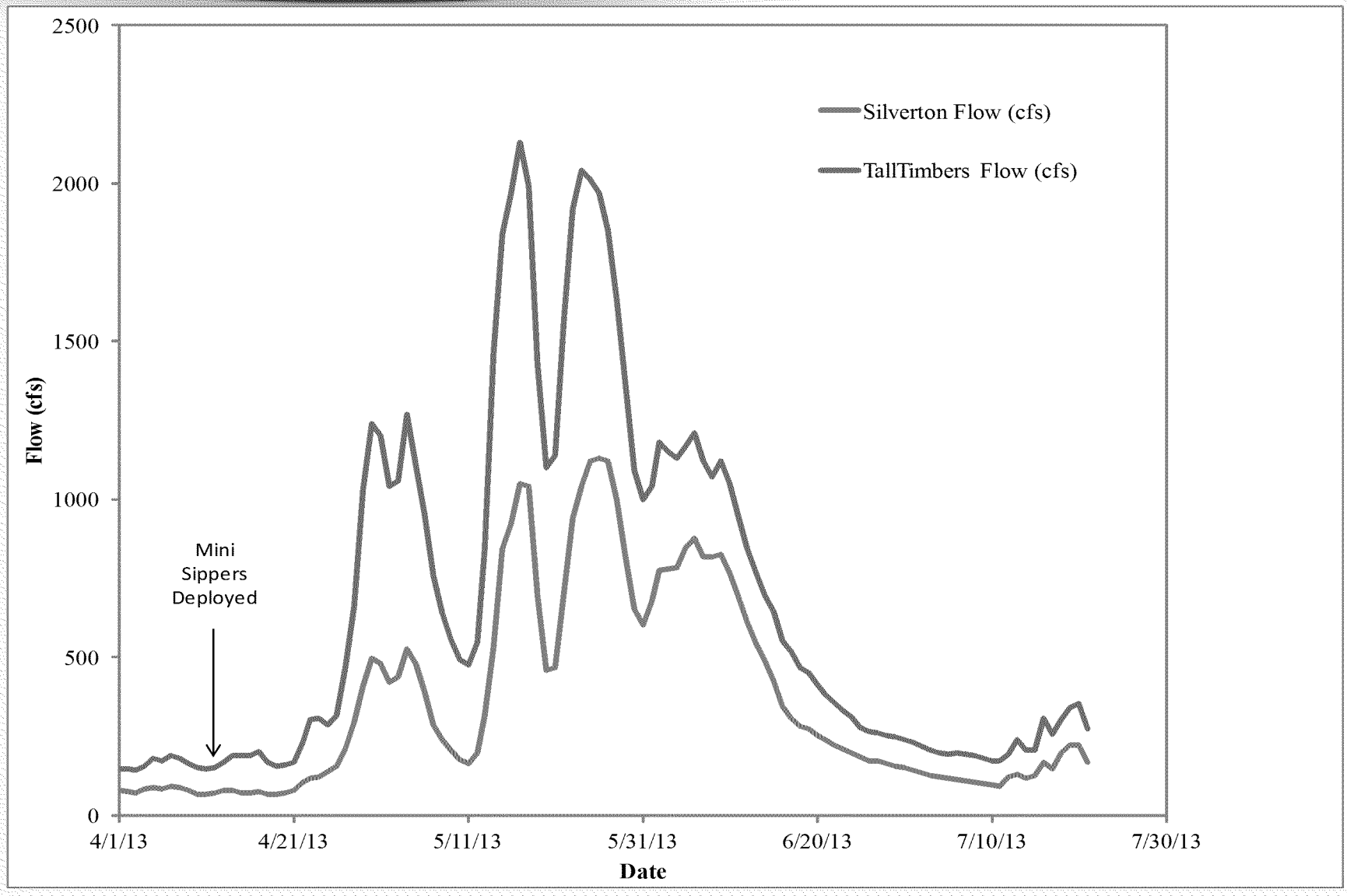
Vertical line represents high end


CFS@A68
CFS@CC48
CFS@A72
CFS@M34
ZnHQ@A72
ZnHQ@A68
ZnHQ@CC48
ZnHQ@M34
2500
2000
1500
1000
500
0
CFS
7
6
5
4
3
2
1
0
HQ

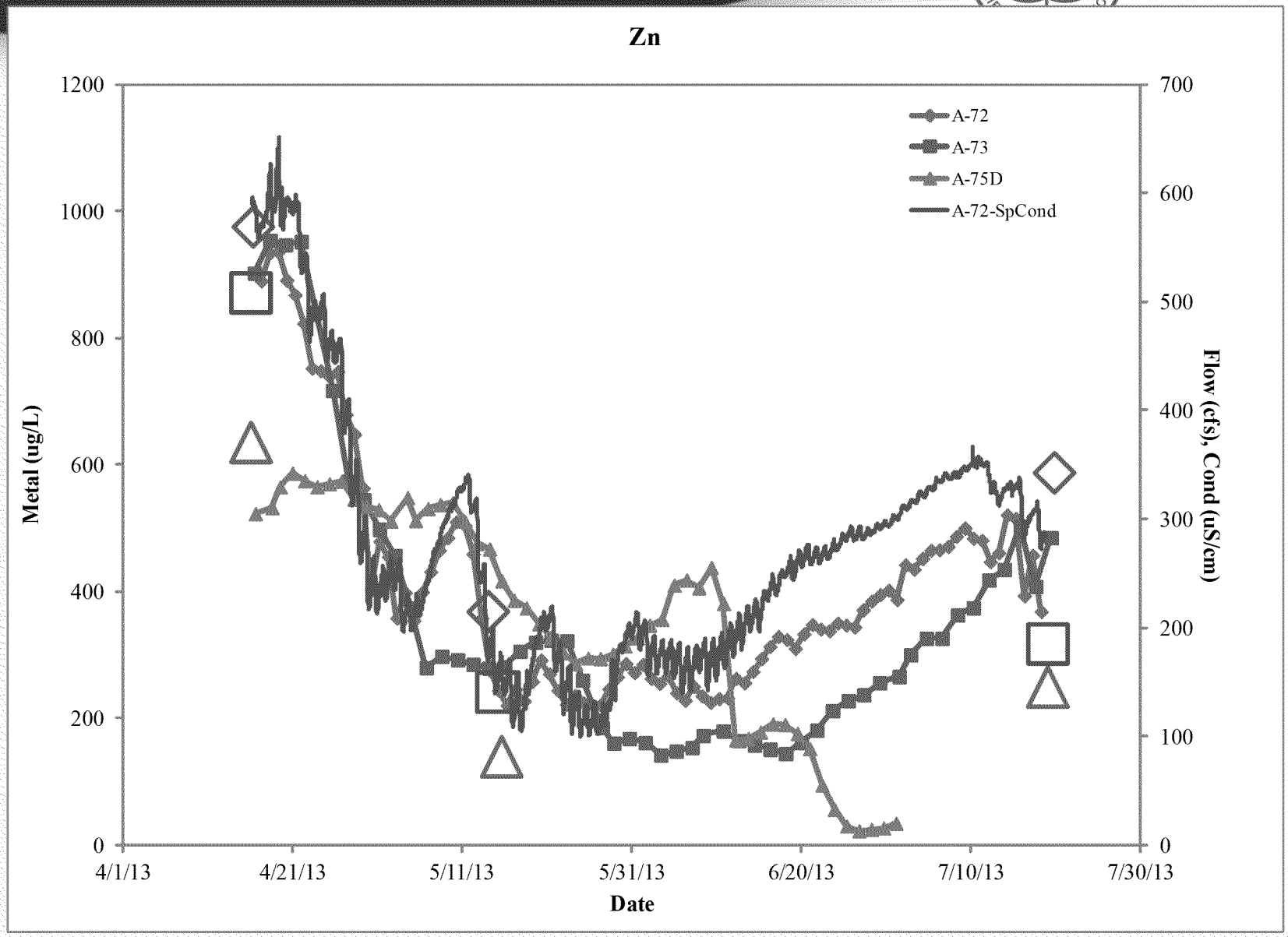
Survival v Biomass



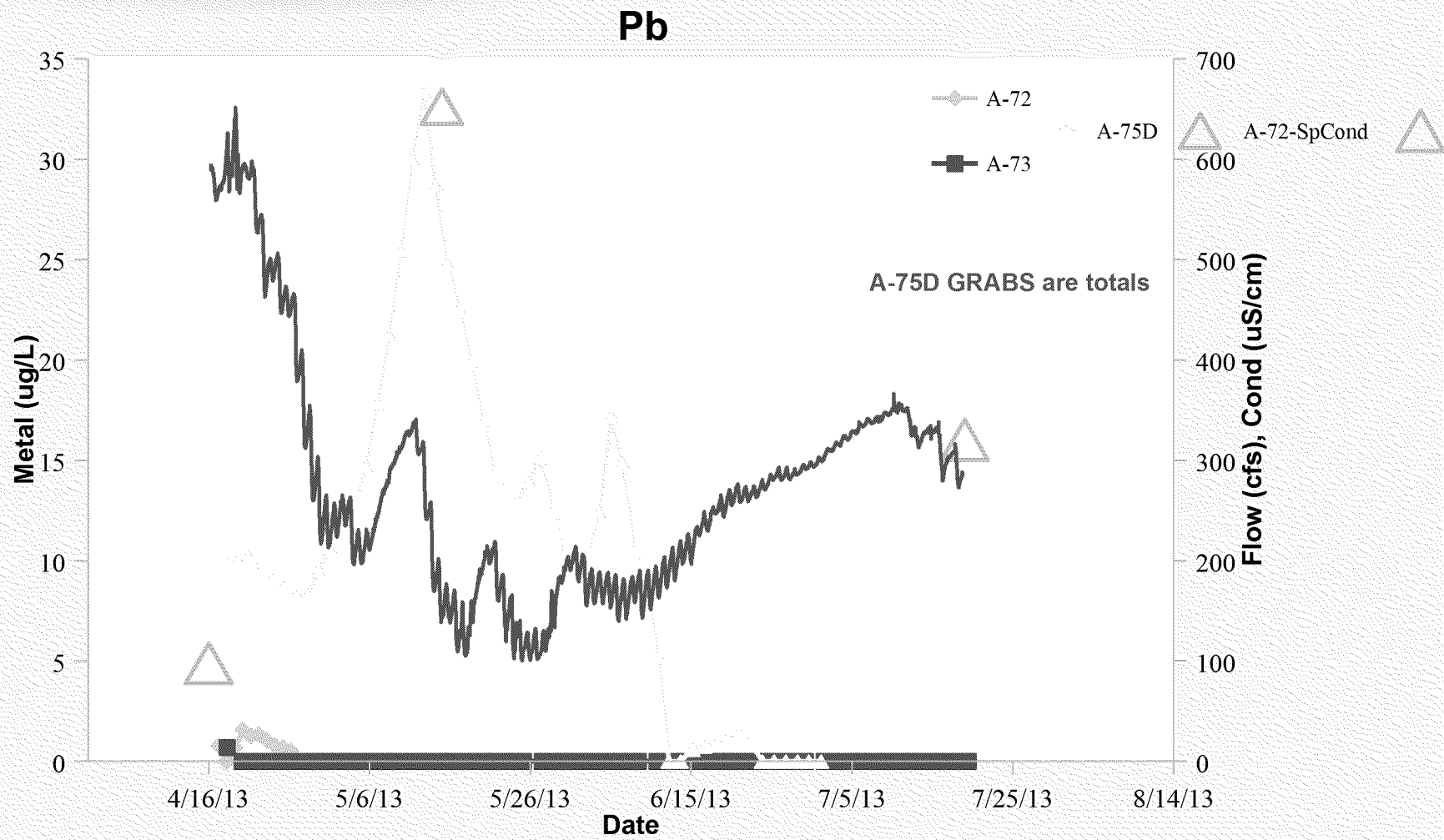
2013 Flows


2500
2000
1500
1000
500
0
Flow (cfs)
Silverton Flow (cfs)
TallTimbers Flow (cfs)
Mini
Sippers
Deployed
4/1/13
4/21/13
5/11/13
5/31/13
6/20/13
7/10/13
7/30/13
Date

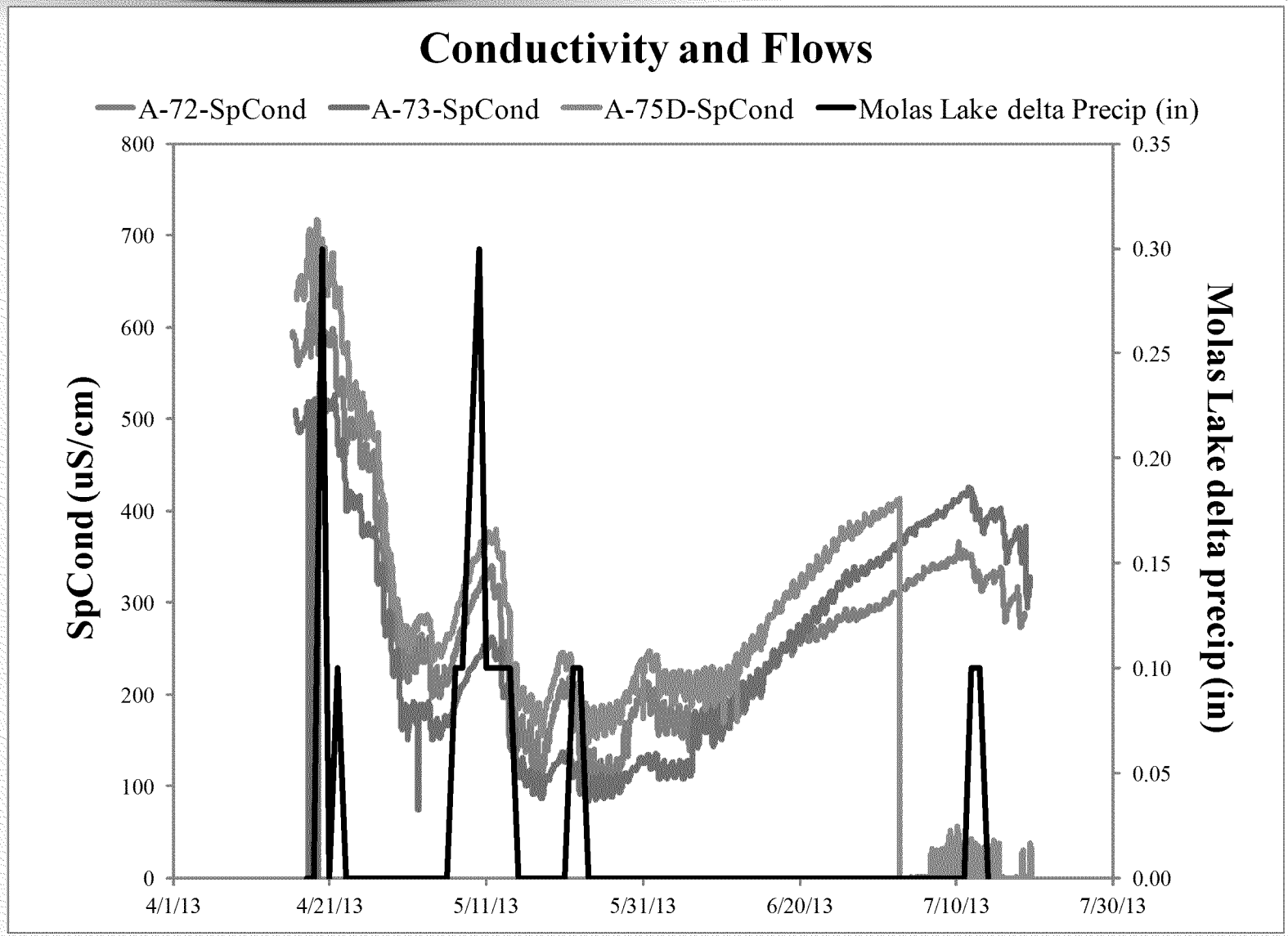
2013 Mini-Sipper Results



Pb 2013


Pb
A-72
A-75D
A-73
A-72-SpCond
A-75D GRABS are totals
Metal (ug/L)
Flow (cfs), Cond (uS/cm)
Date
35
30
25
20
15
10
5
0
700
600
500
400
300
200
100
0
4/16/13
5/6/13
5/26/13
6/15/13
7/5/13
7/25/13
8/14/13

2013 Mini-Sipper Results



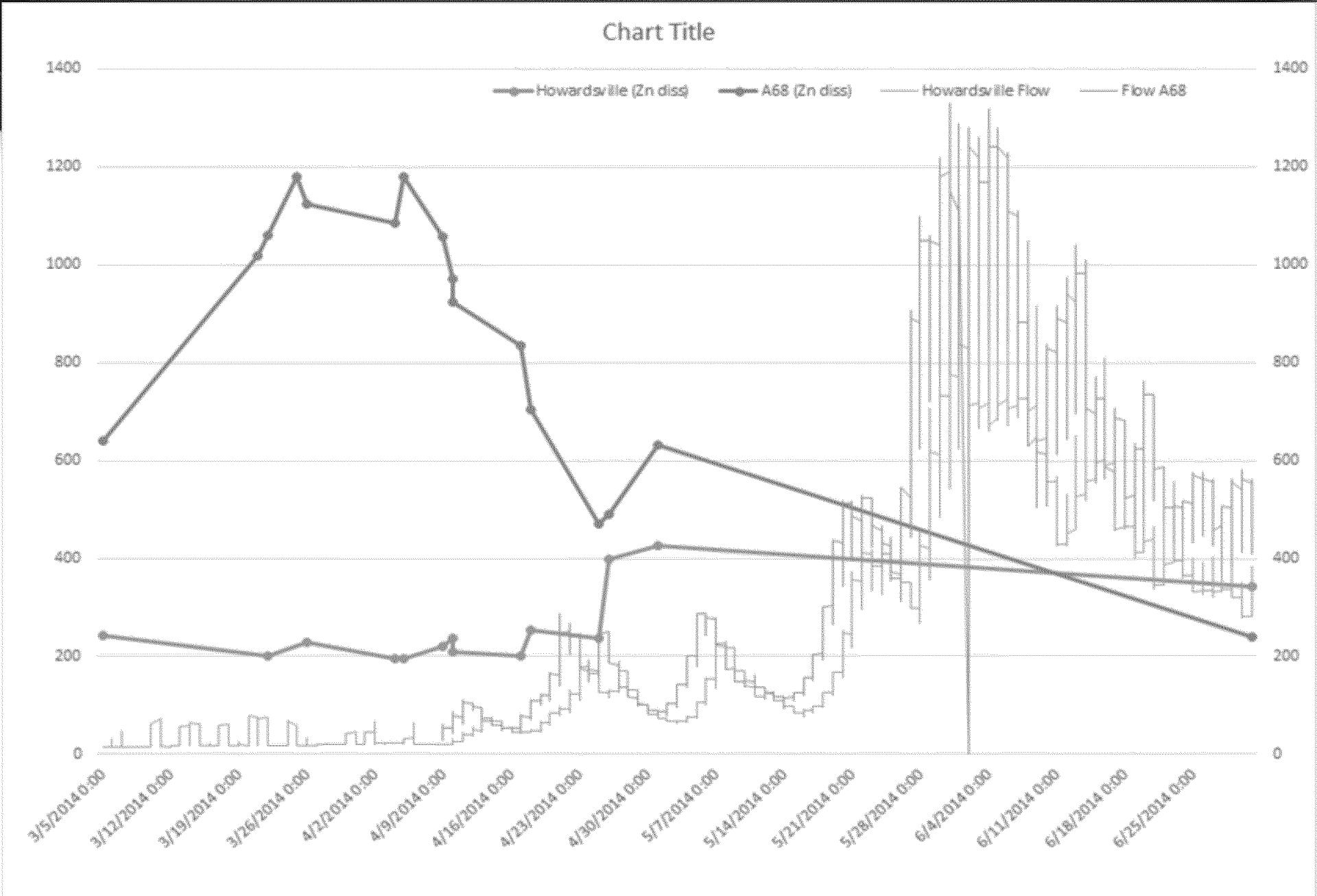
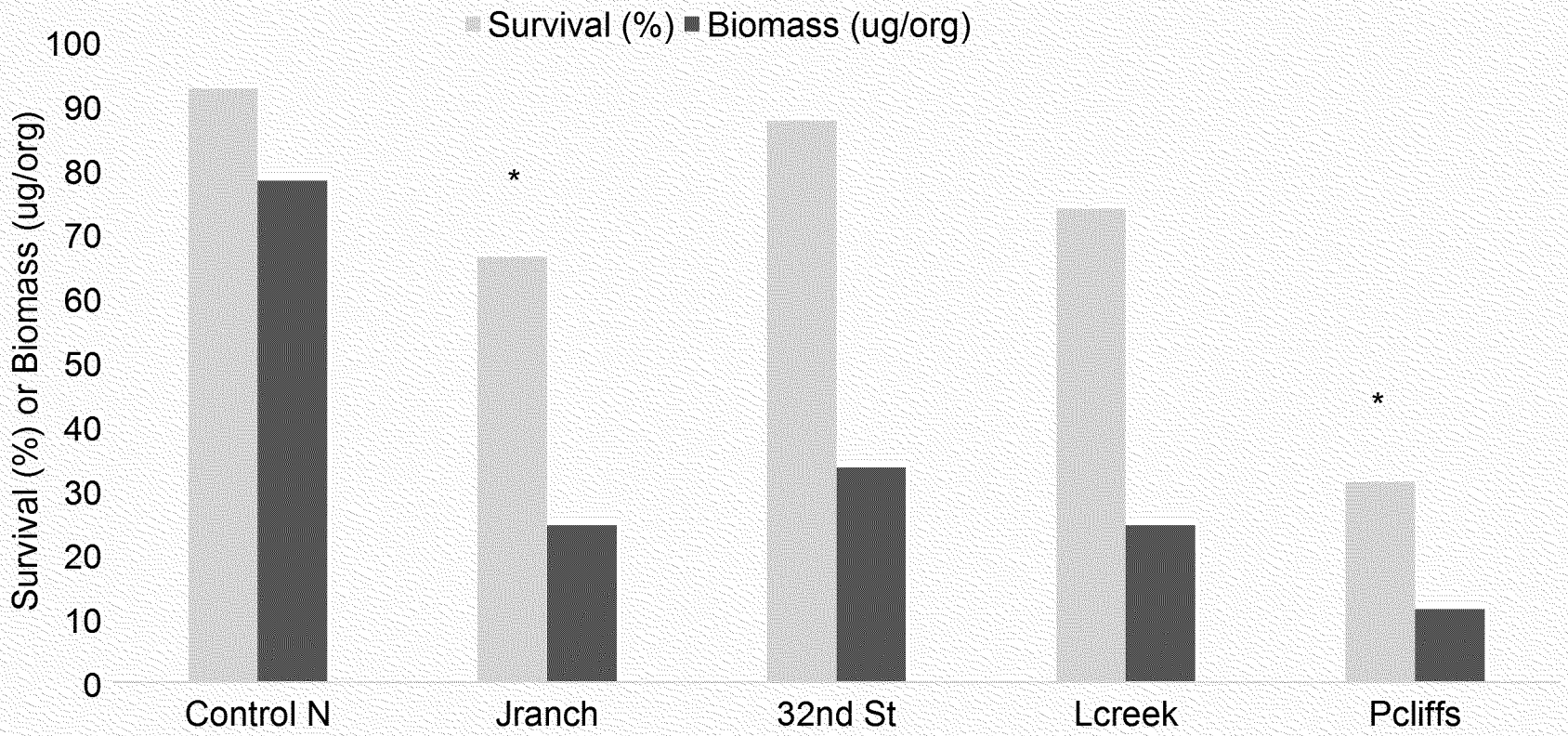


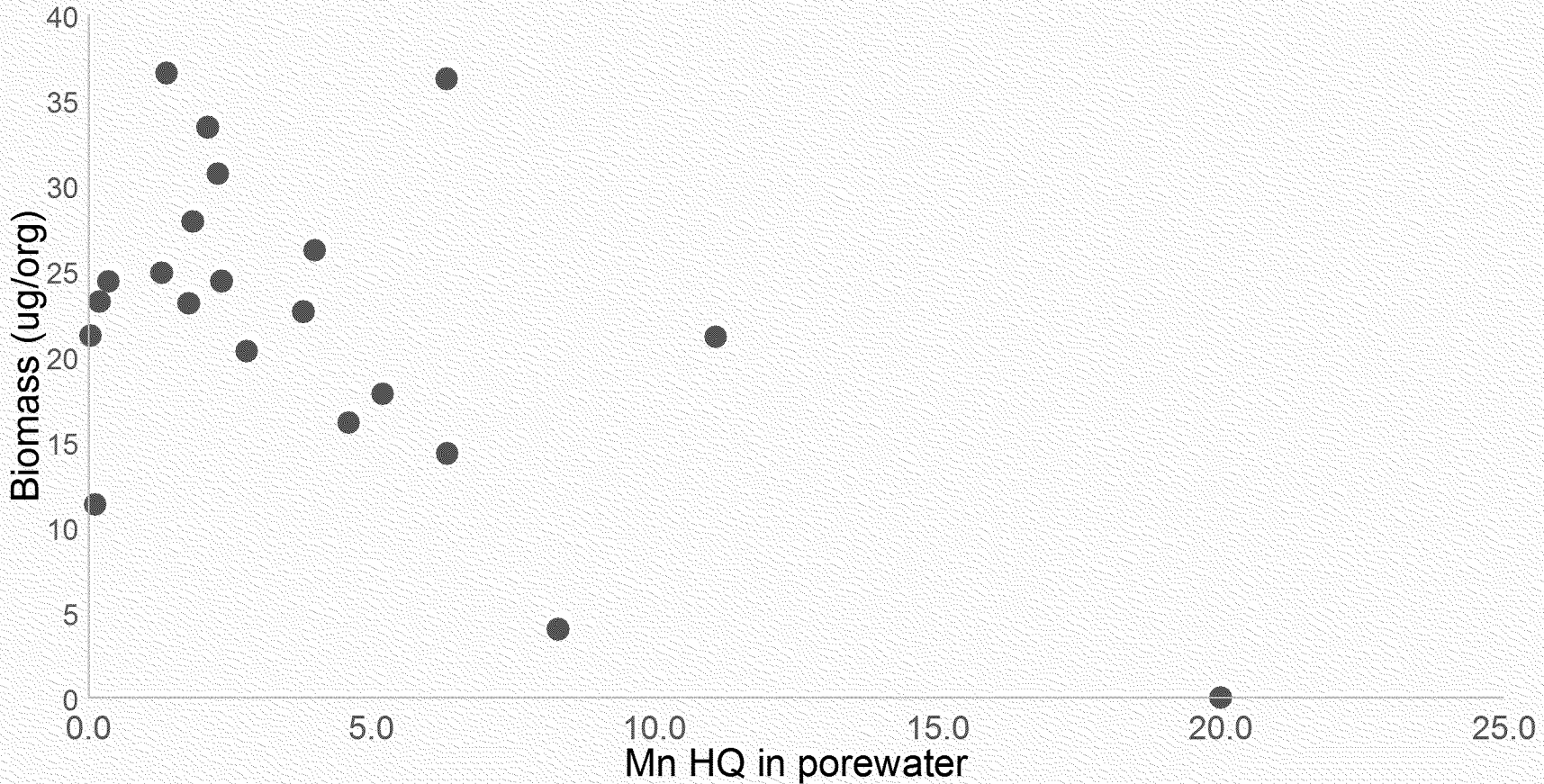
Chart Title
Howardsville (Zn diss)
A68 (Zn diss)
Howardsville Flow
Flow A68
1400
1200
1000
800
600
400
200
0
3/5/2014 0:00
3/12/2014 0:00
3/19/2014 0:00
3/26/2014 0:00
4/2/2014 0:00
4/9/2014 0:00
4/16/2014 0:00
4/23/2014 0:00
4/30/2014 0:00
5/7/2014 0:00
5/14/2014 0:00
5/21/2014 0:00
5/28/2014 0:00
6/4/2014 0:00
6/11/2014 0:00
6/18/2014 0:00
6/25/2014 0:00

2014 Additional Sediment Toxicity Test Results



*statistically different from Control N for Survival results
All Biomass results statistically less than Control N

Biomass v Mn HQs in Porewater ?



Species Sensitivity

Species	*Metal*	Calculated Values at Hardness of 50 mg/L $CaCO_3$		
		LC50 Toxicity Thresholds (f)	*Acute Toxicity Thresholds (g)*	*Chronic Toxicity Thresholds (h)*
Brown Trout	Cadmium	2.43	1.21	0.99
Rainbow Trout	Cadmium	2.67	1.33	1.30
Brook Trout	Cadmium	2.31	1.15	*ACR (i)*
Brook Trout	Copper	45.44	22.72	*ACR (i)*
Brown Trout	Copper	36.09	18.05	16.61
Cutthroat Trout	Copper	48.81	24.41	*ACR (i)*
Rainbow Trout	Copper	26.72	13.36	10.78
Brook Trout	Zinc	1464.91	732.46	627.29
Brown Trout	Zinc	565.83	282.91	346.50
Cutthroat Trout	Zinc	281.93	140.96	107.07
Rainbow Trout	Zinc	242.39	121.19	129.76

- Where the pH is equal to or greater than 7.0 in the receiving water after mixing, the chronic hardness-dependent equation will apply. Where pH is less than 7.0 in the receiving water after mixing, either the 87 µg/l chronic total recoverable aluminum criterion or the criterion resulting from the chronic hardness-dependent equation will apply, whichever is more stringent

Assessment Endpoints

Definition

"……explicit expressions of the environmental values to be protected."

- EPA 1992

Ecological relevance
Sensitivity
Exposure
Management relevance

Measurement Endpoint

Definition

"……a quantifiable ecological characteristic that reflects....effects on the assessment endpoint."

- EPA 1992

Relevance to assessment endpoints
Ecological relevance
Mechanism of toxicity